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JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

STAFF OF THE ARTILLERY SCHOOL.

VOLUME XIII.

1900.

ARTILLERY SCHOOL PRESS
FORT MONROE, VIRGINIA

KF475

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Journal of the United States Artillery.
1900.

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JANUARY—FEBRUARY.
Vol. XIII. No. 1. Whole No. 41.

1900.

[illegible] 30 1900

JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

STAFF OF THE ARTILLERY SCHOOL.

ARTILLERY SCHOOL PRESS,
FORT MONROE, VIRGINIA.

[illegible]

UNITED STATES ARTILLERY SCHOOL,

FORT MONROE, VIRGINIA.

The *Journal of the U. S. Artillery* is published at the Artillery School as a bi-monthly, by authority of the Staff of the School.

COMMITTEE OF DIRECTION AND PUBLICATION.

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Subscription	$2.50
For countries in the postal union	$3.00
Single numbers	$0.50

Remittances should be sent to the editor at Fort Monroe, Va.

AGENTS.

NEW YORK—*Dyrsen & Pfeiffer,* successors to
F. W. Christern, 254 5th Avenue.
LONDON—*B. F. Stevens & Brown,* 4 Trafalgar Square.

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JOURNAL
OF THE
UNITED STATES ARTILLERY.

VOL. XIII. No. 1. JANUARY—FEBRUARY 1900. WHOLE No. 41.

THE WIND PROBLEM IN GUNNERY.

BY A. G. GREENHILL, PROFESSOR OF MATHEMATICS IN THE ORDNANCE COLLEGE, WOOLWICH, ENGLAND.

This subject has received treatment in a very instructive and practical manner by Lieutenant John W. Ruckman, 5th U. S. Artillery, in an article published in the July number of the School of Mines Quarterly, Columbia College, 1896, and also in the *Journal United States Artillery*, Vol. 1, 1892.

As the wind deviation observed is much greater with small arm bullets than artillery projectiles, the subject is one which concerns the infantryman and rifle-shot more than the gunner; but the reason for the variation of the wind deflection with the size of the projectile is still somewhat obscure, and so the present article may prove useful in showing in an elementary manner why this difference should be expected to exist.

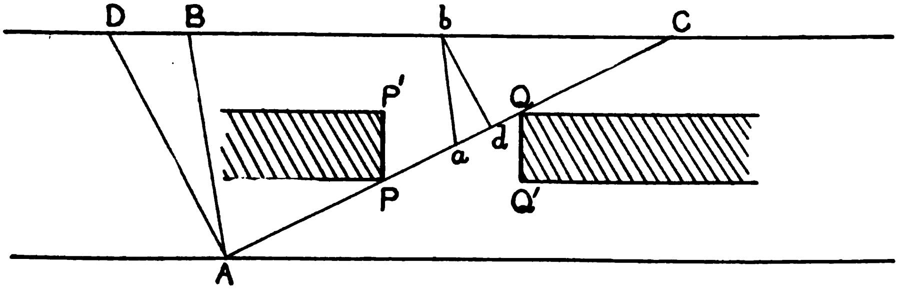
The subject of Wind Deflection is so intimately bound up with the theory of Aberration and of the Speed Sight, that it may be permissible to open up the discussion with an elementary exposition of these theories, suitable for presenting the principles and calculations to the student of Artillery.

The principle of the Speed Sight is employed by us unconsciously in crossing a street crowded with traffic: it will be found on reflection that we are looking in one direction at the vehicles advancing on us, but are directing our steps in a different direction, which may be almost if not quite at right angles to the direction of our eyes, according as the traffic is swift and crowded, and our pace is comparatively slow.

In this case the eyes give instinctively, the direction of the speed sights, required for bodies representing the projectiles, to evade instead of hitting as nearly as possible the vehicles, the equivalent of the target.

Suppose, for instance, that *PP′* represents the rear of a vehicle and *QQ′* the front of the next vehicle, following at an interval of *a* feet, in a stream of traffic moving with velocity *V* feet per second (f/s).

FIG. 1.



A pedestrian crossing the road will just escape being run over if his path relative to the traffic is *APQC*; but to accomplish this he must, while looking out in the direction *AC*, direct his steps in another direction *AB* (Fig. 1).

If *Cb* is drawn to represent to scale the velocity *V*, and if *ba* is drawn parallel to *BA* to meet *CA* in *a*, then *abC* is a triangle of velocities, such that *ab* will represent to the same scale the velocity of the pedestrians across the road.

The least possible length of *ba* is obtained by drawing *bd* perpendicular to *AC*; and with this least permissible velocity the pedestrian walks across the road in the line *AD*, looking all the while at right angles to his path in the direction *AC*.

The same construction will hold for the path of a boat rowed across a tidal stream of the same velocity *V* reversed, when it is required to pass between two vessels at anchor, in the interval represented by *PP′ QQ′*.

PLATFORM FIXED, TARGET MOVING.

Coming now to a gun fired from a fort or fixed platform, at a moving target, the speed sight problem is to determine the direction of the line of sight on the target at the moment of firing, in order that the shot and target should come into collision.

It is simpler to analyse the problem in the reverse order, and starting with the shot in contact with the target, to examine the previous history.

The line *TG* from the target *T* to the gun *G* must be in the

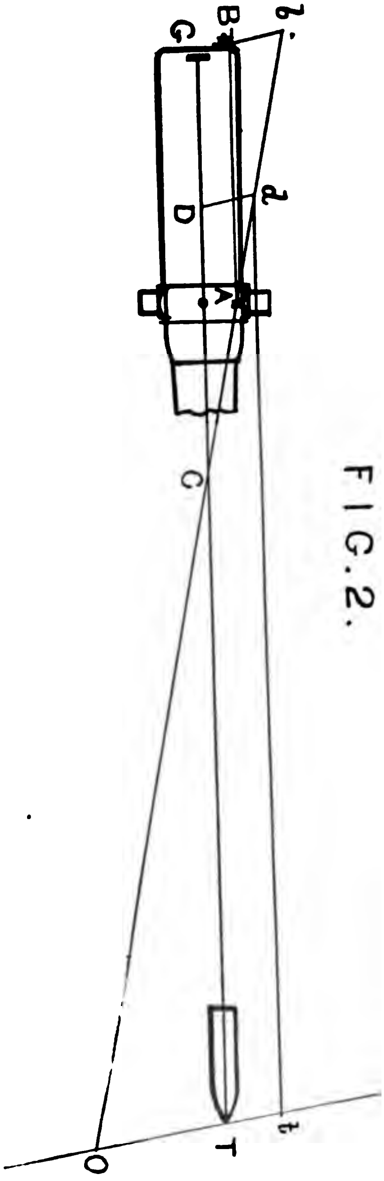


FIG. 2.

prolongation of the axis of the gun (Fig. 2). While the shot was proceeding from the gun *G* to the target *T*, the target was moving in some line OT, where O was the position of the target at the instant the shot was fired. If the time of flight is t seconds, and if the *average* velocity of the shot over the range CT is v f/s, while the velocity of the target is u f/s,

(1) $$CT = vt,\ OT = ut,$$

and

(2) $$\frac{OT}{CT} = \frac{u}{v}.$$

Now suppose A and B are the pivots of the fore-sight and back-sight of the gun. If the back-sight is moved from B, in the *same* direction as the movement of the target, to a position b, such that O, A, and b are in one straight line, then if the gun is fired when the target crosses at O the line of sight bA, the shot and target will arrive simultaneously at T, and a hit will be made.

This presumes for exactness that the time of flight for the average velocity v is reckoned from the instant the shot is passing C; but any delay, due to a slight hang-fire, or to the time occupied by the shot in gradually acquiring velocity in the bore, can be allowed for by supposing the shot to start with full average velocity at some point D further back in the bore, and meanwhile the target would have advanced an additional distance $Tt = Dd$, and the shot would strike this distance behind the point aimed at.

The practical artillerist will see at once that this distance Dd would not amount to an inch or so; and being a constant deviation at all ranges, and not a cumulative deviation increasing with the range, it may be ignored with safety.

The speed-sight deviation for the movement of the target may also be given by moving the fore-sight from A (Fig. 3); but now the deflection must be laid off in the direction *opposite* to the movement of the target; the fore-sight must be moved from A to a, parallel to OT, through a distance

(3) $$Aa = bB.$$

Now if the gun is fired when the target crosses the line of sight Ba at O', the shot and the target arrive simultaneously at T, on the assumption that the shot starts from C' with full average velocity v; but if we must take D as the starting point, the target will have advanced an additional distance $Tt' = Dd'$ when the shot arrives at T; but this deviation from the point aimed at, being a matter of an inch or less, and a constant error and not cumulative, may be ignored in artillery practice.

Any delay or hang-fire thus tends to make the shot strike the target *behind* the point aimed at.

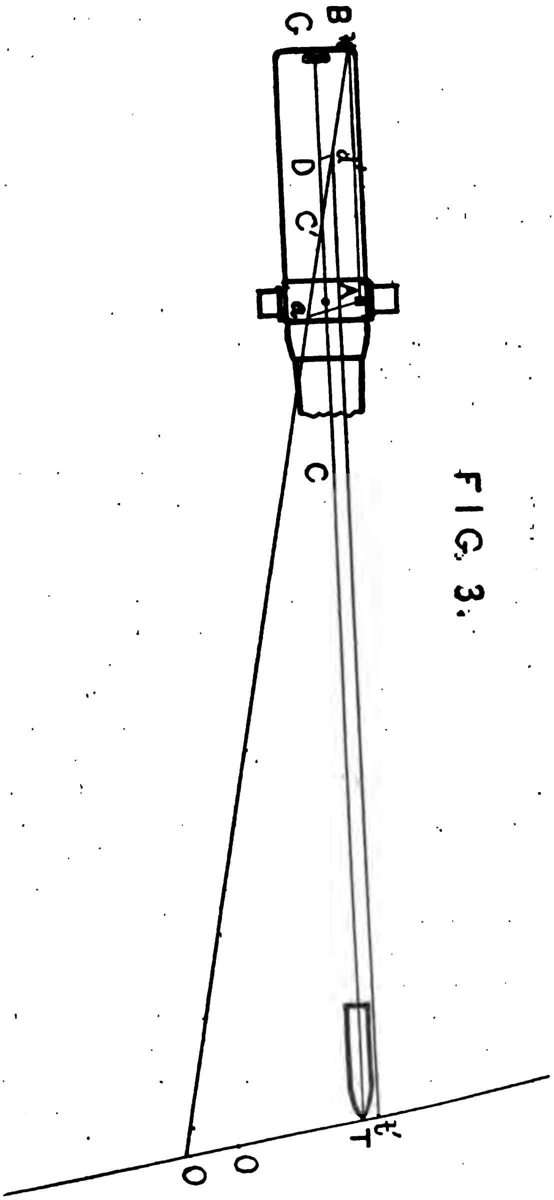


FIG. 3.

In the corresponding mental calculations required in crossing the street between the traffic, any delay in starting after the direction of movement has been decided, and then bolting across is likely to lead to disaster.

PLATFORM MOVING AND TARGET FIXED.

This is the speed problem as required in naval practice from a ship, steaming round a fixed target or engaging a fort.

The speed correction is made by a deflection of the front sight, in the *same* direction as the movement of the platform, through a distance Aa parallel to the velocity U of the platform, and of length such that (Fig. 4)

$$(4) \qquad \frac{Aa}{AB} = \frac{U}{V},$$

where V denotes the *muzzle* velocity of the shot.

If the gun is fired when the line of sight Ba is on the point t of the target, and if F is the point in the bore from which the shot may be supposed to start with full speed V, then the combination of this velocity with the velocity of the platform will cause the shot in issuing from the muzzle to take up a direction over the water parallel to Ba, the actual path being FT parallel to Ba; so that now the effect of any delay or hang-fire is to cause the shot to strike in front of the point aimed at, at a slight distance Tt which does not increase with the range, and which is small enough to be ignored in artillery practice.

On the assumption of uniform acceleration of the shot up the bore, the average velocity in the bore is half the muzzle velocity; this would place F at a distance from the muzzle double the distance of the shot from the muzzle when the gun is loaded.

The same deflection can be given on the back-sight B, by a displacement Bb (Fig. 4) equal and parallel to Aa, but laid off in the direction *opposite* to the motion of the platform. This is the method usually employed with naval speed sights; hence the words—move the H aft—placed on the speed sight of naval guns, the H representing, from its shape, the sliding sight on the top of the leaf (Fig. 5).

If it is considered desirable as diminishing confusion to make each deflection in the *same* direction as the motion it is intended to correct, then the back-sight should be moved to allow for the movement of the target, and the front-sight for the movement of the platform.

But if the back-sight is to give deflection for platform velocity, and the front-sight the deflection for the target velocity, these deflections must be laid off in the direction contrary to the motion each is intended to correct.

The possibility of confusion has led nowadays to the suppression of the deflection scale on the front-sight *A*, both corrections being made on the back-sight *B*.

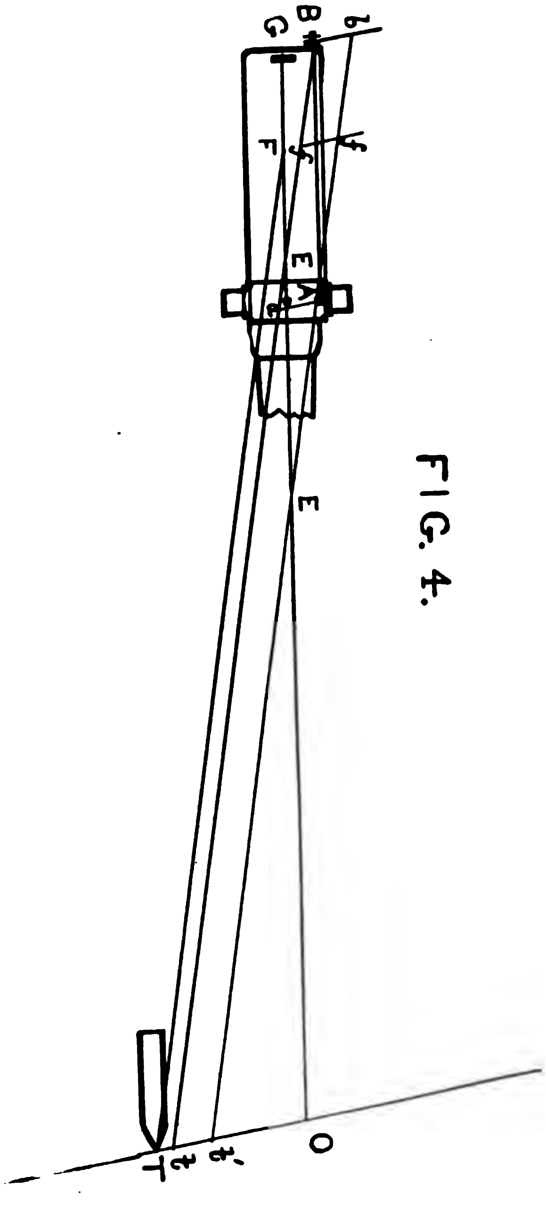


FIG. 4.

The scale for platform deflection is graduated in *knots*, and to call attention to the deflection being opposite to the motion of the platform, the words—move the **H** aft—are cut on the scale. As for the deflection required for the speed of the target, it is laid off in the same direction, in minutes and degress of angle also cut on the scale; and it is assumed that the minutes of deflection required will be the minutes through which the line of sight of the target would turn during the time of flight of the shot, if the gun was laid from a fixed platform on the moving target.

To graduate the scale *Bb* for knots, taking a knot as a speed of 100 feet per minute ($\frac{5}{8}$ f/s) or a nautical mile as 1000 fathom of 6 feet, then a graduation bb' must be such that

$$(5) \qquad \frac{bb'}{AB} = \frac{\frac{5}{8}}{V}.$$

Thus if $V = 2000$ f/s, and $AB = 6$ feet, or 72 inches, then

$$(6) \qquad bb' = \frac{\frac{5}{8} \times 72}{2000} = 0.06 \text{ inches};$$

and now the scale is graduated uniformly by this interval for knots of speed of the platform.

To graduate the scale *Aa* of the front-sight for speed in knots of the target, a graduation aa' must be such that

$$(7) \qquad \frac{aa'}{AB} = \frac{\frac{5}{8}}{v},$$

where v is the *average* velocity of the shot over the range of the target, obtained by dividing the range in feet by the time of flight in seconds, or practically by looking out in the range-table the remaining velocity at the half-range.

These graduations of the front-sight would thus be suitable for one range only, taken usually as a medium range of 1500 or 2000 yards.

Thus if $v = 1200$ f/s, as for a 3-pounder Q.F. gun, then

$$(8) \qquad aa' = \frac{\frac{5}{8} \times 72}{1200} = 0.1 \text{ inches},$$

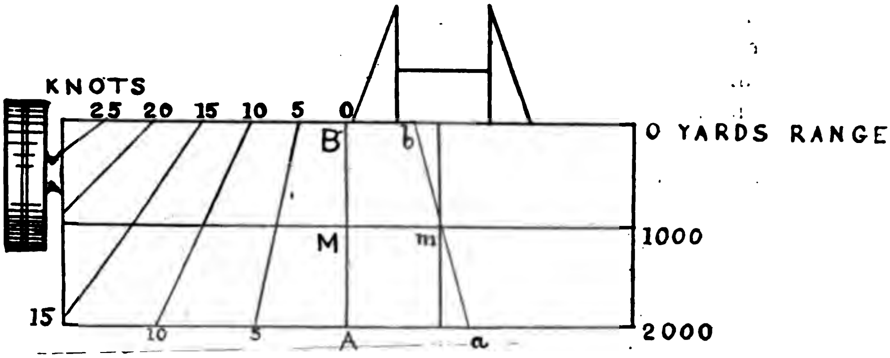
the interval of the graduation for knots speed of the target at this range.

The graduations of the two speed sights *Aa* and *Bb* are thus different, and the sights are not interchangeable, another source of confusion.

But it is possible to combine both scales of deflection on one leaf by splaying out the lines of graduation, as shown in Fig. 5.

The scale *Aa* is placed below the scale *Bb* and parallel to it, with *AB* vertical; and now if corresponding graduations *a* and *b* are joined by a straight line, the target deflection at any other range *Mm* will be given by the graduation *m* in which the line *ab* cuts *Mm*, at least near enough for practical purposes.

FIG. 5.



The theory of the instrument would be exact on Mr. Bashforth's working assumption of a time of flight *t* seconds expressible by a quadratic function of the range *s* in feet, as

(9) $$t = as + bs^2,$$

equivalent to assuming a resistance of the air varying as the cube of the velocity.

For differentiating,

(10) $$\frac{dt}{ds} = a + 2bs,$$

(11) $$\frac{d^2t}{ds^2} = 2b,$$

and

(12) $$\frac{d^2t}{ds^2} = -\frac{d^2t}{ds^2}\left(\frac{ds}{dt}\right)^3 = -2b\left(\frac{ds}{dt}\right)^3.$$

If *V* denotes the muzzle velocity, and *v* the *average* velocity over the range *s*,

(13) $$\frac{1}{V} = a,$$

(14) $$\frac{1}{v} = \frac{t}{s} = a + bs,$$

and the graduations *aa'*, being inversely proportional to *v*, are therefore directly proportional to $a + bs$, and therefore increase uniformly with the range; thence we infer that the lines of graduation *ab* may be drawn straight, or that the scales *Aa* and *Bb* having been cut, the scale *Mm* of any other range may be cut by the straight line *ab* in the corresponding point *m*.

In using this sight, the H is moved *aft* along the scale *Bb* of zero range through the graduations corresponding to the speed of the platform, and then the H is moved along the scale *Aa* corresponding to the range of the target, through the additional graduations for the speed of the target, and in the *same* direction as the motion of the target; the resultant of these two movements will give the requisite deflection; this deflection will be the sum of the two separate deflections when target and platform are moving in opposite directions; but when they are moving in the same direction, the deflection will be the difference of the two separate deflections.

When both deflections are given, as here, on the same leaf, it is tacitly assumed that the platform and target are moving in parallel lines, and also, as shown in Figs. 2, 3, 4, that the leaf is placed parallel to this direction.

If these velocities deviate slightly, an average direction between them may be taken as a compromise.

As usually constructed, the leaf of a speed sight is fixed at right angles to the axis of the bore, implying use on a broadside gun with small training fore and aft, and also implying a target moving directly across the range.

But for use on a gun mounted for all round fire on a ship, fore and aft as well as broadside, or for a torpedo carriage, the deflection leaf must be pivoted so as to be placed parallel with the keel, if required to act with any pretence to accuracy.

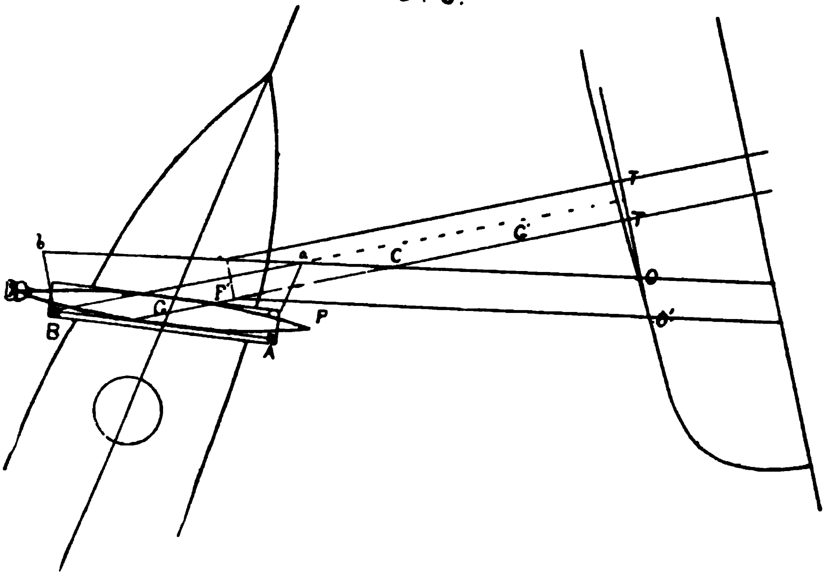
Many artillerists are of opinion that the use of speed sights on guns causes confusion and trouble, and does more harm than good, more than they are worth.

But there can be no doubt as to the necessity of speed sights on torpedo carriages, because the speed of the automobile torpedo through the water is not very different from that of the platform and target, in this case the attacking torpedo boat and the vessel attacked.

The deflection scales *Aa* and *Bb* must now be of about the same length as the radius arm *AB*, and the necessity of pivoting the leaves about *A* and *B* will be manifest from the following theory, which will illustrate and explain the use of speed sights in the most general case, as applied to a torpedo carriage mounted on a torpedo boat, attacking a vessel itself in movement (Fig. 6).

Deflection is now given on both sights; the leaf *Aa* of the front sight is placed parallel to the keel of the torpedo boat, and

FIG. 6.



deflection *Aa* is given, in the same direction as the velocity of the boat, such that

$$(15)\quad \frac{Aa}{AB} = \frac{\text{velocity of torpedo boat through the water}}{\text{velocity of projection of the torpedo}};$$

and now the torpedo will be discharged at the water in the direction *Ba*, and will strike the ship at a point *T*, which at the moment of discharge was behind at *O*, such that

$$(16)\quad \frac{TO}{aT} = \frac{\text{velocity of ship}}{\text{average velocity of torpedo through the water}}.$$

In order that the sights should be aligned on *O* at the instant of discharge, the leaf *Bb* must be placed parallel to *OT*, and the deflection *Bb* must be given in the *same* direction as the ship's way, such that

$$(17)\quad \frac{Bb}{Ba} = \frac{TO}{aT}.$$

Provided the way of the torpedo is unchecked over the course through the water

$$(18)\quad \frac{Ba}{AB} = \frac{\text{velocity of torpedo through water}}{\text{velocity of discharge}},$$

and this makes

$$(19)\qquad \frac{Bb}{AB} = \frac{\text{velocity of ship attacked}}{\text{velocity of discharge}}.$$

We thus see that if the deflections are laid off properly on the speed sights, any error due to delay on firing, or to the consideration of different points of the torpedo, is merely a slight constant error, the same at all ranges, and small enough to make no practical difference when the damage due to a fair hit is considered.

But any error in putting on the speed sight allowance gives rise to a cumulative error, growing with the range, and the chance of the torpedo being thrown away is increased.

We must analyse the movement of the elongated Whitehead torpedo through the surrounding water, complicated as it is by the sidelong broadside component of the velocity with which it is projected into the water, in consequence of being discharged from a tube mounted on a moving platform, in this case the deck of the torpedo boat.

If this broadside component of discharge is excessive there is a chance that the torpedo will lose its stability of forward movement, and will tend to advance in a sidelong manner and lose all directive influence.

But with sufficient gyrostatic domination in the interior, similar to that imparted to the elongated shot in the air by the spin of the rifling, the torpedo in the water, like the elongated shot in the air, will, if assisted by automatic devices, perform gyrations round the direction of projection, and at the same time the center of gravity will describe a sinuous helical path about an axis in the same direction of resultant momentum.

These gyrations and sinuosities will tend to extinction in consequence of the friction of the surrounding medium, water or air; so that with sufficient automatic and gyrostatic control or spin, the torpedo or the elongated shot will tend to steady down, like a sleeping top, to an axial movement in the direction of the resultant impulse of projection.

We may assume then that, at a moderate distance from the torpedo boat, the torpedo will be moving nearly axially in the line GG', and that the point P will strike the ship at T'.

After these preliminaries we arrive at the main object of this article as the investigation of the effect of Wind on the deviation of the projectiles; and this is carried out by assimilating the motion of an elongated shot in a sidelong wind to that of a Whitehead torpedo, discharged in a slightly broadside direction through the water.

This method of explanation of Wind Deflection was suggested by the late Captain F. Younghusband, R. N., Superintendent of the Gun Factories in Woolwich Arsenal; it has the advantage of placing in a very clear light the reason of the greater wind deflection experienced by small arm bullets compared with artillery projectiles.

A somewhat similar explanation, applied to spherical projectiles, will be found in Didion's *Traité de Balistique*, 1860, p. 392.

Suppose then that an elongated shot is discharged from a gun G on a fixed platform at a mark T on a fixed target, through a wind blowing with uniform velocity W f/s straight across the range GT.

The motion of the shot through the air is exactly the same as if the shot had been projected through still air with forward axial velocity V f/s, and sidelong velocity W f/s, up the wind.

The shot at first performs gyrations round the direction of resultant projection; these gyrations are audible with a bullet fired into a strong cross-wind.

But the gyrations soon die out, and the shot steadies itself down into an axial movement through the air, inclined up the wind at an angle $\tan^{-1} W/V$ with the axis of the bore. A target at a range of R yards or $3R$ feet, moving down with the wind, will be struck at a point $3R \tan d$ or $3RW/V$ feet from the point aimed at when the gun was fired, this deflection on the moving target being up the wind. With a time of flight of t seconds, a fixed target will be Wt feet up the wind, behind the moving target; and therefore the deflection on the fixed target from the point aimed at will be, down the wind, a distance

$$(20) \qquad Wt - 3R\frac{W}{V} = W\left(t - \frac{3R}{V}\right) \text{feet.}$$

In other words, the wind deflection is

$$(21) \qquad W(t - T) \text{ feet,}$$

where t is the actual time of flight, and $T = 3R/V$ is the time of flight over the range of R yards or $3R$ feet, provided the initial velocity V f/s keeps up undiminished over the range.

The time $t - T$ may be called the *delay* over the range: the wind deflection is thus the distance the particles of air have moved during this delay.

The time of flight t is found in the Range Table; the time t and the delay $t - T$ increase as the ballistic coefficient $C = w/nd^2$ is diminished; and now we see why wind deflection is greatest with small arm bullets, and becomes less as the size, weight and ballistic coefficient of the projectile is increased.

The following scheme shows the deflection to be expected, in accordance with this theory, at a range of 1000 yards of shot of various sizes, all fired with the same initial velocity $V = 2000$ f/s, so that $T = 1.5$ seconds, taking a wind of 30 knots, or $W = 50$ f/s.

	Small-arm bullet.	3 pr. Q. F. gun.	6 inch.	12 inch.
t	3.0	1.876	1.616	1.563
$t-T$	1.5	0.376	0.116	0.063
$W(t-T)$	75 feet.	18 feet.	6 feet.	3 feet.

Calculation of Wind Deflection.

1000 yards.

	3 pr. Q. F.	6 inch.	12 Inch.
w	3.4	100	714
d	1.85	6	12
$\log d$	0.2672	0.7782	1.0792
$\log d^2$	0.5344	1.5564	2.1584
$\log w$	0.5315	2.0000	2.8537
$\log C$	$\bar{1}.9971$	0.4436	0.6953
$S = 3000.$ $\log S$	3.4771	3.4771	3.4771
$\log \frac{S}{C}$	3.4800	3.0335	2.7818
$\frac{S}{C}$	3020	1080	605
$V = 2000.$ S_V	45207.1	45207	45207
S_v	42187.1	44127	44602
v	1300	1723	1841

Referring to Lieutenant Ruckman's paper for the data of the 15-inch solid spherical shot, fired with velocity $V = 1700$ f/s, and having a time of flight of $t = 8$ seconds over a range of 3000 yards, so that

$$T = \frac{9000}{1700} = 5.3 \text{ seconds,}$$

the wind deflection according to the formula above, for a wind blowing at 10 miles an hour, or

CALCULATION OF WIND DEFLECTION.—*Continued.*

1000 yards.

	3 pr. Q. F.	6 inch.	12 inch.
T_V	233.4956	233.4956	233.4956
T_v	231.6071	232.9137	233.1805
$\frac{t}{C}$	1.8885	0.5819	0.3151
$\log \frac{t}{C}$	0.2761	$\bar{1}.7649$	$\bar{1}.4984$
$\log C$	$\bar{1}.9971$	0.4436	0.6953
$\log t$	0.2732	0.2085	0.1937
t	1.876	1.616	1.563
T	1.5	1.5	1.5
$t—T$	0.376	0.116	0.063
W	50	50	50
$W(t—T)$	17.800	5.800	3.150
	18 feet	6 feet	3 feet
$\log 3000$	3.4771	3.4771	3.4771
$\log t$	0.2732	0.2085	0.1937
$\log v$	3.2039	3.2686	3.2834
U	1600	1857	1921
v	1300	1723	1881

$$W = \frac{44}{3} \text{ f/s},$$

would be

$$W(t - T) = \frac{44}{3} \times 2.7 = 39.6 \text{ feet},$$

or about half the deflection, 25 yards, assigned by Lieutenant Ruckman.

But the velocity of the wind is known to increase very rapidly with the height above the ground, as seen by the drift of the clouds, so that a wind of 10 miles an hour at the level of the muzzle would probably increase to double this velocity at the average height of the shot in the air, and this would make Lieutenant Ruckman's result fall into line with observed results.

For a wind W blowing diagonally down the range, making an angle a with the line of fire, calculate the component velocities of the wind, $W \cos a$ straight down the range, and $W \sin a$ across the range.

Now calculate the time of flight t over the range R when the initial velocity through the air is reduced from V to $V - W \cos a$; or look out t from the range table, starting from the point where the remaining velocity is given as $V - W \cos a$, and looking forwards an additional R yards; the wind deflection is now

$$W \sin a \, (t - T) \text{ feet,}$$

where

$$T = \frac{3R}{V - W \cos a} \text{ seconds.}$$

More accurately, we ought to calculate t as the time of flight with an initial velocity $V - W \cos a$, of a shot to a target advancing towards the gun at a velocity $W \cos a$, the gun being fired when the target was at a range of R yards.

Captain Zalinski's Wind Dial shows the components of deflection for varying directions of the wind, and exhibits in a convenient form the reducing factor $\sin a$ (Fig. 7).

His coefficient for a wind blowing straight across the range, a III or IX o'clock wind, is, I find, like Lieutenant Ruckman's, about double the value assigned by the preceding theory; but this discrepancy I should explain by the rapid increase of the wind velocity with the height of the bullet in the trajectory; so that the wind to be allowed for is about double the wind experienced near the ground.

In a gun provided with two speed sights *Aa* and *Bb*, the front sight being graduated for the speed of the target and the back sight for the speed of the platform, the wind correction can be made by giving the deflection of the wind velocity on both sights, in each case up or against the wind. If the sights are interchanged, the deflections must be laid off down or with the wind.

The single speed sight described in Fig. 5 is also suitable for giving wind deflection at any range, if the **H** is first moved against the wind to the graduation corresponding to the wind velocity on the scale *Aa* of the range, and then moved down the wind on the scale *bB* of zero range, again through the number of graduations on *bB* corresponding to the wind velocity.

In consequence of the divergence of the lines *ab*, the final position of the **H** will be *up* the wind, measured from the line of zero deflection *AB*, and this position will give the requisite wind deflection.

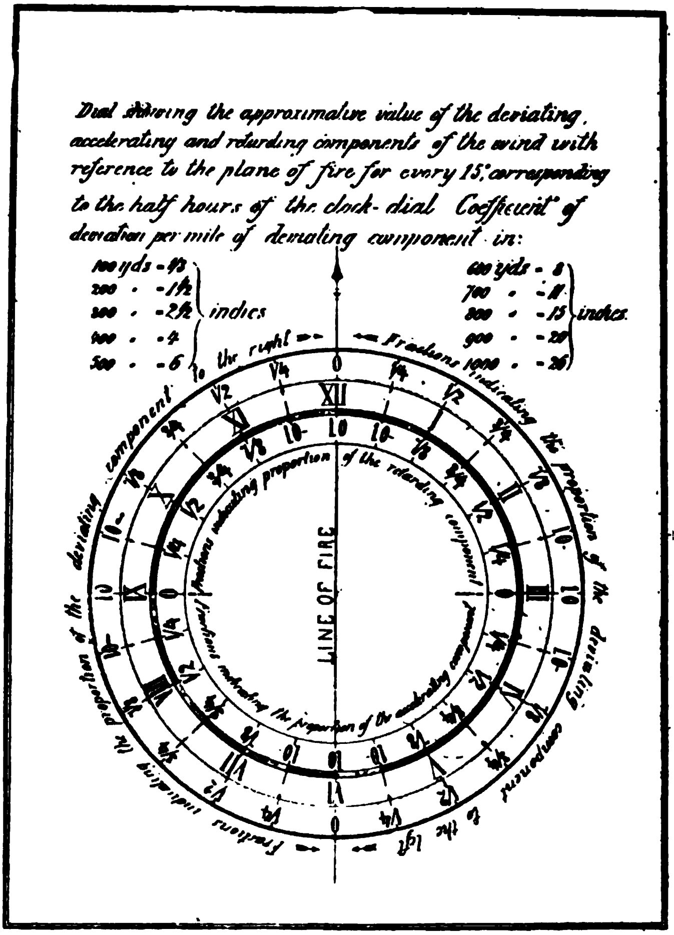
Two ships engaging abeam, steaming with the same speed in parallel courses, would require this deflection corresponding to the apparent wind they create.

The co-efficients are for the service cartridge of 405 gr. bullet, 70 grains powder. It supposes that the rifleman can judge, approximatively, the velocity of the wind, in miles per hour. Example to illustrate use of dial, etc.:

Range = 500 yards
Velocity wind = 18 miles
Direction = XI

Co-efficient for 500 yards = 6″.·. Sight allowance = $\frac{18}{2} \times 6 = 54'' +$ drift $= 54'' + 5''.2 = 59''.2$.

FIG. 7.



Dial showing the approximative value of the deviating, accelerating and retarding components of the wind with reference to the plane of fire for every 15° corresponding to the half hours of the clock-dial. Coefficient of deviation per mile of deviating component in:

100 yds - ⅓
200 · - 1½
300 · - 2½
400 · - 4
500 · - 6
indics
600 yds - 8
700 · - 11
800 · - 15
900 · - 20
1000 · - 26
inches
to the right
Fractions indicating the proportion of the deviating component
to the right
Fractions indicating the proportion of the deviating component
Fractions indicating the proportion of the retarding component
Fractions indicating the proportion of the accelerating component
LINE OF FIRE
XII
XI
X
IX
VIII
VII
VI
V
IV
III
II
I
0
1/4
1/2
3/4
1.0

Theoretical values at 600 yards = 9.33
" " " 700 yards = 12.25
" " " 800 yards = 15.87
" " " 1000 yards = 24.24
" " " 900 yards = 19.9,
others are very near to above.

Practical artillerists, like Captain Zaliniski, who are interested in these refinements of wind correction, are invited to make a trial of the deflection sight described in Fig. 5. A piece of card-board can be ruled into the requisite graduations, and fixed on the leaf of the back-sight without interfering with any existing arrangements; in this way a trial can be made of the practical utility of the method.

AUTO-SIGHTING.

BY COLONEL SIR G. S. CLARKE, K.C.M.G., F.R.S., R.E.

Reprinted from *Proceedings Royal Artillery Institution*.

In the "Proceedings ' of the *R. A. Institution*, for June, 1898*, Colonel H. S. S. Watkin, C. B., gives a most lucid explanation of the principles involved in auto-sighting, and provides diagrams showing two partial solutions of the problem. That problem may be shortly defined as follows :

Given the height of the gun above the sea-level at any moment, the angle of depression of the line of sight evidently determines the range. It is required, by mechanical arrangements connecting the line of sight with the gun, to ensure that when the former is laid on the water-line of any floating target, the latter shall automatically take up the quadrant elevation corresponding to the range. As the tail cannot wag the dog, so the sight must be moved by the gun, the latter being elevated or depressed till the former comes "on" with the target.

Such are the theoretical conditions to be fulfilled; but subsidiary difficulties are involved. It is necessary, in all cases where the rise and fall of tide is considerable, to provide a suitable correction. It is further necessary to be able to correct for the various disturbing causes comprehended in the term "error of the day," causes which combine to prevent the gun from shooting true to its range table.

While I have nothing but admiration for Colonel Watkin's handling of the theoretical considerations appertaining to auto-sighting, I disagree absolutely with his conclusions that auto-sights are of use only in exceptional cases and that there is "danger" in "supposing that they can take the place generally of the present methods of laying guns." The only danger, in my opinion, is that the immense advantages which auto-sighting offers to the Garrison Artilleryman may not be adequately and promptly realized. As large numbers of auto-sights are in course of manufacture, it seems desirable to attempt to allay the misgivings to which Colonel Watkin's able paper must evidently give rise.

His forebodings are based upon the two following objections:

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*Reprinted in *Journal U. S. Artillery*, No. 40.

1. The errors of observation are so great that accuracy cannot be expected.
2. The "serious errors" due to eccentricities on the part of the "racers" will suffice to vitiate auto-sighting even if (1) could be eliminated.

I propose to deal with these two objections.

1. "The actual errors of laying an automatic sight in 1897 when tried by a committee of experts" are given in a tabular form and present an alarming appearance. With a height of gun of 153 feet, the error recorded at 3,500 yards was 890 yards, which is evidently prohibitive. The auto-sight employed was, however, merely a device for moving the back sight. The line was taken by the unaided eye over sights of service type. If such sights were affixed to the excellent D.R.F. or P.F. instrument, I think that the errors would be found to be surprising; but this only proves that, except at comparatively short ranges, the unaided eye is prone to deceive, and even the difference between a "fine" and a "full" sight is considerable. With the D.R.F. and the P.F., therefore, a telescope was found to be essential. In the case of an auto-sight, the same need obviously arises, and for the same cause. As Colonel Watkin points out "in certain weathers, in fog and with powder smoke hanging about, a telescope cannot always be used with advantage;" but there will not be much "powder smoke" in the actions of the near future, and as regards certain weathers and fog, what is sauce for the D.R.F. or P.F. is clearly sauce for the auto-sight. Practical experience has brought out in the most striking way the fact that the telescope could be most effectively used in conditions which rendered ordinary sights absolutely useless. Except in case of short ranges, a telescope is an essential feature of an auto sight, and the failure to recognize this axiom is the reason that neither of the arrangements described by Colonel Watkins can fulfill the necessary requirements. Auto-sighting apart, the telescope sight which has hitherto been a monopoly of the mounted branches, will prove an immense gain to the Garrison gunner. The purely observation errors introduced will be no more and no less than those which arise in using the D.R.F.

2. The question of securing the verticality of the axis about which the gun traverses is extremely important; but I am inclined to demur to the expression "want of level of the emplacement, platform, etc.," which suggests that half-a-dozen or more things have to be accurately adjusted. Auto-sighting, if the best results are to be obtained from it, demands that the

level of the racer path shall be true within narrow limits. Its application "to the older form of guns and platforms is out of the question," as Colonel Watkin quite correctly states. It would obviously be unsuited to a 64-pr. on a Garrison standing carriage; it would confer no advantage on a 9-in. R. M. L. gun standing on weak and wavy racers. I well remember an expensive fort in which the rear racers of slight section were attached to wooden chocks *nailed* between floor joists! In such a case and in many others I should certainly not recommend any attempt to employ auto-sighting. We are not, however, concerned with the past. It would be unprofitable to apply a water-tube boiler to a Newcomen engine or a quick-firing breech mechanism to a demi-culverin. An invention can justly be criticised only in regard to the conditions of the times at which it appears.

Colonel Watkin has given figures showing the effect in the case of a 6-in. gun of tilting the racer path "4′ down to the point," the assumed height of the gun being fifty feet. In this case at 4,000 yards, the range-finding angle—that is the angle of depression of the line of sight—is 14.3′. Deducting 4′, we have a range-finding angle corresponding to 5,564 yards, and at 5,564 yards 4′ will shorten the range by thirty-two yards. The range obtained, in these conditions, will therefore be 5,532 yards, involving an error of 5,532 — 4,000 yards = + 1,532 yards.

The tilting of the racer path is, however, much more likely to be in the other direction, or down to the rear because the effect of recoil creates this tendency. If 4′ is added to the range-finding angle of 14.3′, the corresponding range is 3,131 yards. Adding forty-five yards due to the increase of 4′ the range becomes 3,176 and the error is 3,176 — 4,000 yards = — 824 yards. Such an error is of course inadmissible; but it differs materially from 1,535 yards, and might, therefore, have received mention in an analysis of the situation. It should also be noticed that the error tends to diminish rapidly as the range-finding angle approximates to the angle of descent.

While an inspection of Colonel Watkin's table would naturally lead to the conclusion that an inclination of 4′ would render the use of an auto-sight impossible, the actual facts differ materially. I am inclined to think that the auto-sight has been regarded as a range-finder and criticised from this point of view. This is clearly a misconception. A range-finder is an instrument for finding and *accurately recording* ranges. It does not concern itself with the shooting of the gun and such matters. On the other hand, the auto-sight is a device enabling a range-finder to be dispensed with. It has nothing to no with the recording of ranges and it must take account of conditions which the range-finder ignores.

No gun shoots exactly to its range table and for various reasons there arises what is conveniently if vaguely called the "error of the day." Theory lends us no assistance in eliminating this error, and we have to fall back upon the method employed by our ancestors long before sights or range-finders were in existence. In other words, we must observe the fall of the projectile, estimate the error of range and correct accordingly. The auto-sight provides the means of correcting in accordance with such an observation, and evidently errors due to inclination of the racer path are included in the correction.

For example, if with a 6-inch Q. F. gun at a height of fifty feet standing on a racer path inclined 4′ forwards, the correction can be made from an observation at 4,000 yards, the errors going up the range are:

Range.	Errors in range.
1,000	— 32 yards.
2,000	— 37 "
3,000	— 25 "
4,000	0 "

If the racer path is inclined backwards the errors would be practically the same in amount but +.

If the correction is made from an observation at 3,000 yards, the table on the previous page becomes:

Range.	Errors in range.	Vertical error.
1,000	— 30 yards	— 2·9 feet.
2,000	— 34 "	— 5 "
3,000	0 "	0 "
4,000	+ 38 "	+ 13.6 "

I need hardly point out that the above tables assume that firing proceeds on the line of training at which the correcting observation is made; but my object is to show that the hypothetical defect on which Colonel Watkin dwells is not inherent in the principle of auto-sighting and that the amount of error introduced depends practically upon whether the gun is fired approximately on one line of training or whether that line varies through a wide angle. This error would, therefore, not prevent accurate practice either at a stationary target, or at a target moving in a tolerably direct line towards or away from the gun. The auto-sight is, in fact, not by any means so helpless as it has been made to appear. At the same time, the question of maintaining the verticality of the axis of the mounting is one that every auto-sight inventor must evidently face.

I cordially agree that the application of auto-sighting to "the older nature of guns and platforms" would be useless, and I have made no attempt to design a sight for these interesting memorials of a by-gone age. Since the days when the 9-in., 10-in. and 12·5-in. R. M. L. guns were made, we and other Powers have moved far and fast. These guns in their day were excellent. That day has now passed and we have to meet new conditions. If our coast artillery is called upon to fight, its opponents will be armed with the best modern weapons whose speed of fire and accuracy is immensely superior to that of the short R. M. L. ordnance. Thus the 2d class cruiser *Eclipse* steaming at sixteen knots on a course parallel to a straight coast line and passing 1,200 yards from a coast battery could, at peace practice, fire about:

168 rounds 6-inch Q. F. inside 4,000 yards range.
242 rounds 4·7-inch Q. F. inside 4,000 yards range.
412 rounds 12-pr. Q. F. inside 3,000 yards range.

There is nothing in these figures to cause alarm. It would be easy with a single 6-in. Q. F. gun provided with an auto-sight to put forty shell into the *Eclipse* during the fourteen minutes she would be within 4,000 yards, when steaming at this speed and being hulled three times a minute, her chances of hitting a target eighteen square feet in area would be remote. But a battery of (say) four 9-in. R. M. L. guns and two 64prs. worked by P. F. using Case III. would apparently be somewhat heavily handicapped in engaging such a vessel in free maneuvering waters.

The weapons which coast artillery can now call to its aid are the 6-pr., 12-pr., 4·7-in. and 6-in. Q. F. and the 9·2-in. and 10-in. B. L. I believe that the 9·2-in. B. L. of latest type with a muzzle velocity of 2,700 f. s. represents the *maximum* power necessary for the defence of our ports, and that a sacrifice of the immense advantage of speed of fire receives no adequate compensation in the employment of a heavier projectile. At the same time, I consider that the weapon *par excellence* of coast artillery is the 6 in. Q. F. gun with a muzzle velocity not less than 2,800 f. s., supplemented by the 12-pr. Q. F.* The slightest study of the recent bombardments of San Juan and Santiago, confirming all previous experience, serves to show how moderate are the requirements of coast defence. Quality of ordnance and training of men are the matters of real importance. Half a dozen 6-in. Q. F. guns capably handled would have more than sufficed for every requirement of Santiago attacked by a fleet containing five modern battleships. Whatever view may be adopted in regard to this larger question, it will, I think, be generally admitted that in discussing the advantages of auto-sighting, we must take into consideration modern ordnance rather than converted 64-prs. on blocked up platforms, or 9-in. R. M. L. on switch-back racers. How, therefore, do we stand as regards the mountings of what are entitled to rank as modern guns?

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* As a protection to confined interior waters against torpedo-boat raids, the 6-pr. Q. F. may suffice.

Existing H. P. mountings may be put aside as, except in cases of temporary aberration, their sites are too low for effective auto-sighting. For them the best method of laying at present available is evidently the straight edge foresight and V back sight employed with elevation indicator and D. R. F. or P. F. used as range-finder. Their present need is a non-recoiling carriage sight. All Q. F. guns, 3-pr. to 6-in., are free from the incubus of the "platform," to which Colonel Watkin refers, and all can be levelled without difficulty. The 6-in. B. L., Mark I. and Vavasseur C. P. stand upon cast steel roller paths which admit of correction. The Mark I. and II. 9·2-in. and Mark III. 10-in. are not hopeful subjects for adjustment if their racer paths are out of level. I have described my recent designs,* and it will be noticed that in every case I have provided a solid cast iron pedestal with the special object of securing rigidity. These mountings can always be adjusted for level if settlement occurs after the pedestals have been fixed. In addition, it is possible to provide a simple mechanical arrangement, which corrects throughout 360° of training, for any ascertained deviation from the vertical. Summing up, therefore, Colonel Watkin's objection does not apply to any 3-pr., 6-pr., 12-pr., 4·7-in. and 6-in. Q. F. guns, or to any 6-in. B. L. and 9·2-in. B. L. or mountings of recent design. If, as I contend, it is the future and not the past that we must take into consideration, the application of auto-sighting is hampered by no restrictions.

It is pleasant to pass from the domain of theory into that of ascertained fact. Two of my auto-sights went straight from the R. C. D. shops to an out-station where they were fitted by the local artificers to two 4·7 mountings, not of R. C. D. design or manufacture. The roller paths were levelled, the sights adjusted, and a few rounds fired. On the following day, the trials began. The conditions throughout the practice were officially reported to be "the worst conceivable for laying, from bad light, mist and boisterous winds." At moderate ranges the target could not be seen with the unaided eye. The following are the results obtained in the rapid fire series using the telescope:

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* "Proceedings" *R. A. Institution*, November, 1897.

A. RANGE 1167 YARDS.

Round.	+ — yards.	*R* or *L* yards.
1	+ 25	5 *L*
2	+ 30	5 *L*
3	+ 25	5 *L*
4	+ 25	5 *L*
5	+ 30	5 *L*

Time 37·72 seconds.

B. RANGE 1954 YARDS.

Round.	+ — yards.	*R* or *L* yards.
1	+ 8	8 *L*
2	+ 10	8 *L*
3	+ 10	8 *L*
4	+ 13	8 *L*
5	+ 10	8 *L*

Time 41·96 seconds.

C. RANGE 3050 YARDS.

1	+ 5	1 *R*
2	+ 5	1 *L*
3	+ 5	Line
4	Range	"
5	+ 10	1 *L*
6	+ 2	2 *L*
7	+ 2	1 *L*
8	+ 10	Line
9	+ 1	"
10	+ 2	"

Time 1 min. 42·6 secs.

D. RANGE 3775 YARDS.

1	Range	Line
2	+ 1	"
3	+ 7	"
4	+ 15	"
5	+ 30	"
6	+ 30	"
7	+ 30	"
8	+ 80	"
9	+ 80	"
10	+ 10	"

Time not taken because layer's eye was tired.

During D series the target was scarcely visible with good glasses.

The ranges of the targets were taken with D. R. F. The fall of the shell was noted by range party on board a steamer.

A practical result of this kind outweighs much theory.

Coast artillery can now be provided with:

9·2-in. guns firing 1 round per minute.
6-in. " " 5 " " "
4·7-in. " " 7 " " "
12-pr. " " 10 " " "

If full value is to be obtained from these guns, auto-sighting is evidently essential. To apply to them "the present method [illegible] is equivalent to putting a [illegible] jockey on a Derby winner. [illegible] The [illegible]-sight [illegible]

NOTE ON THE EMPLOYMENT OF SCALED ELEVATIONS IN COAST ARTILLERY FIRING.

Reprinted from *Rivista di Artiglieria e Genio.*

It is generally admitted that in the firing of field as in that of siege artillery, it may sometimes be advantageous to fire over a zone of ground (in which the target is certainly located) with successively scaled elevations, rather than to seek to fire exclusively at the target with an adjusted fire.

The necessity for making haste and the difficulty or impossibility of judging with certainty the results of the firing are the reasons which sometimes determine or impose the scaling of the elevations. When, however, by adjusting the fire upon the target we either risk losing precious time or concentrating the shots upon some point other than the target, it may may be expedient to seek to attack with a few of the shots scaled, but this should be accomplished quickly and with certainty. The power of modern projectiles—shrapnel or shell—is such that a few of these bursting in the vicinity of the target suffices to produce an effect, great in itself, though small in comparison with the number of projectiles employed. With R. F. guns then, we will obtain, in a short time, that definite number of useful shots which suffices to give the result fixed upon.

The fire with scaled elevations is by many, by the greater number even, admitted in exceptional cases only. Nevertheless it has found favor in France ; many artillerists, among them some of incontestable authority, maintain that in war there will often be occasions when that kind of fire may be advantageously applied, so that this class of firing may become the rule and adjusted firing the exception. The notes which have reached us on the management of the experiments made in France with a new field piece, create the belief that the principle of scaled firing, by zones, *d raffiche*, as it is called, must have a broad application in the firing regulations of that piece.

The conditions of Coast Artillery firing are different from those of Field or Siege Artillery firing.

Indeed, some of its characteristics seem to be those which may be classified as essentially geometrical firing, and exclude, therefore, the idea of attacking the zone in which the target is located rather than the target itself. These characteristics include the facility and certainty of observing the shots ; the possibility of measuring the distance of the target with an accuracy not to be hoped for in the other kind of firing ; the relatively limited number of shots available and, finally, the fact that the projectiles act only at the points hit.

Notwithstanding these characteristics, other circumstances, such as the mobility and kind of mobility of the target, and the necessity which sometimes presents itself in this kind of firing more than in other kinds, of firing quickly, have induced some to seek whether or not it was important to adopt scaled elevations also for Coast Artillery. Be it understood that in this case, we would not treat of volleys fired with successively increasing and decreasing elevations, but of shots fired in the same volley with different elevations.

Towards the latter part of 1886, General Celestino Rossi expressed the opinion "that we must endeavor to attack with simultaneous fire areas limited by the possibility of motion of the vessel and by the errors in the measurement of the distances."[*]

General Rossi had been led to this idea by the small probabilities of fire which he attributed to mortars, accepting the conclusions of a known work by Major De Luca.[†] These conclusions were, however, deduced upon the hypothesis that Coast Artillery would adopt for its fire, methods very different from those which in 1886 were already for some time in use. General Rossi finally admits the necessity for dispersed firing, but not so firmly as to demonstrate or discuss it analytically.

Figure 1a shows the normal type of sea coast mortar batteries adopted in the United States. It is formed of 16 pieces placed in groups of 4 each ; the centers of the groups are placed at the angles of a rectangle 80 by 40 yards. The pieces are all laid parallel to each other according to data of elevation and direction which would only be exact for an hypothetical piece located at the center of the rectangle. The fire is thus scaled in direction as well as in range. This is the only example we know of Coast Artillery fire scaled in a normal and permanent manner. Concerning this battery and the advantages or disadvantages which it presents in comparison with another whose pieces are pointed at the target independently of each other, there has been for some time back a keen discussion in America.*

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[*] Some ideas upon the defense of special sea coast localities against attacks from the sea. (*Revisita di Art. e Genio*, 1886, volume II, page 494).

[†] Upon the action of modern artillery in naval and sea coast fights (*Rivista Marittima*, anno 1886.)

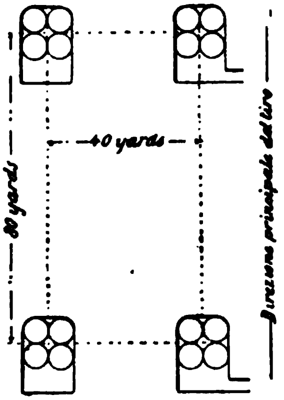

Fig 1ª

Finally Lieutenant Calichiopulo in various valuable articles published in this *Review* and especially in that which appeared in the March, 1899 number, has sought to demonstrate by calculations the advantages which scaled firing would present in Coast Artillery firing.†

We are not, however, entirely in accord either with the methods of calculations which he adopted, nor with the conclusions which he reached. We are therefore forced to take up anew the question studied by him.

* * * * *

The errors which have an influence in the firing of Sea Coast Artillery may be divided into two groups:

1. The accidental errors, which determine the dispersion about the center of the volley, of the shots comprising it, the pieces of the volley being all fired with the same data. Such are the errors of pointing due to the piece, to slight irregularities in the charge and projectile, and to others of a similar nature; the errors, in fact, on which the width of the 50 per cent. zone depends. In discussing the fire of a battery, we will admit that all

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* See the following articles in the *Journal* of the United States Artillery:

Sea coast mortar fire; (volume VII, page 287).

The probability of hit when the probable error in aim is known; with a comparison of the probabilities of hit by the methods of independent and parallel fire from mortar batteries; (volume VIII, page 129).

A reply to the report of a board on sea-coast mortar fire; (volume VIII, page 142).

† Considerations upon the probability of coast and marine artillery fire. (1893, volume I, page 245). Considerations upon the fire control of sea-coast batteries. (1897, volume I, page 187). Scaled fire for Coast Artillery. (1899, volume III, page 422).

the pieces are in exactly the same condition, so that when they are fired with the same data their trajectories will bear constant relations to each other.

2. The errors which displace the centers of single volleys from the center of the target. These may be separated into three classes :

a. The accidental errors committed in determining the range and direction by means of the range finder. These errors are not due to the mere use of the instrument. As has been shown before, they are functions of the latter, depending upon the calculations which must be made to obtain from the data measured with the instrument, the distance of the instrument from the piece, that from the target, and the range.*

b. The errors due to various systematic causes which tend to alter the range or trajectory, such as inaccurate leveling of the range finder, effect of wind, variations in the density of the air, the condition of the powder, etc. As is finally noted, these corrections, varying continually, become only approximate for the special conditions of fire against a target in motion, and may be either positive or negative. It follows as an effect of the causes of this class of errors, that the paths of the shots formed by a single volley will not be systematically displaced in a certain direction, but will oscillate around the true position of the target. Except, then, for the first shot or shots the fire may always be considered as centered. The result is the same as if a new cause of errors were added to those of the preceding class, producing deviations of a contrary sign and variable value according to a law which can not be determined.

c. The methods of preparation for firing in this country and, as far as known, in other countries also, presuppose that the movement of the target is rectilinear and uniform. It is possible that this double hypothesis will not always be verified, as the route of the target may change after the shot is fired. It may, therefore, theoretically at least, take any position, between certain limits, around the point for which the firing was prepared. Instead of considering the displacement of the target, we may, without altering the result, assume that the centers of the volleys are displaced as though affected by a new cause of errors. This, too, as in the preceding case, is difficult or impossible to estimate with accuracy. We can not calculate rigorously the dispersion of the shots due to all these unequal causes, of which some are scarcely definable and always variable and uncertain in their effects. Whilst the law of accidental errors is perfectly admissible for those which are inherent in the piece, for those due to aiming, and for those due to the use of the particular range finding appliances, it is impossible to determine what law governs those due to the wind, to the unforseen movements of the target and to other causes of a similar nature. Having therefore to make an hypothesis which is the least possible removed from the truth, we will assume that all the deviations, by whatever cause produced, vary according to the law of accidental errors.

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* Ricci. Contribution to the study of the probability of fire of sea-coast artillery. (See *Rivista* 1894, volume XXXIII, page 406).

In order to justify somewhat these hypotheses, we make two observations: 1. The deviations due to the state of the atmosphere, to that of the charge and to other similar causes, depend in a great measure upon the differences between the deviations which these causes tend to produce and those previously calculated on the basis of a measure made and suggested by the error according to the law mentioned above.

2. The vessels will not deviate much, nor very often, from a rectilinear route and uniform velocity, either because they would diminish too much the probability of fire of their own artillery, or, in the few special cases, because of the difficulty of maneuvering or, because of the hydrographical conditions of the sheet of water over which they must move.*

For the same reasons it seems admissible that the propability of a deviation will be as much the greater as its value is the less ; this constitutes a notable analogy with the law of accidental errors. Finally, we have made this hypothesis because it seemed to us no less improbable than others, and because, at the same time, it is the most convenient for calculations. The reasoning which we have followed might likewise be employed with any other law which be adopted for the manner of varrying the deviations.

The classification of the various causes of error which have an influence upon coast artillery firing is fundamental to the study which we wish to pursue.

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* In forcing a passage, the first concern of the vessels will be to move as quickly as possible through the danger zone, it is therefore improbable that it will lose time to execute changes of direction and velocity. In fighting against direct batteries with a view to silencing their guns, it is generally advisable, in order not to diminish too much the efficiency of its own fire, that the vessel move slowly or remain motionless, preferably the latter. Only in the bombardment of broad spaces, where we have to fear mortar fire, is it advisable to fire while in motion, varying continually the direction and velocity. When, however, it is desired to cause the maximum damage, the bombardment should be made either when the vessel is stationary or when it nas but a slow motion.

Admitting that the errors of every kind to which a battery of coast artillery is subject, vary according to the law of accidental errors, the dispersion will be represented by the known curve of Laplace whose equation is

$$y = e^{-\frac{x^2}{\pi H^2}}$$

in which H is the mean error resulting from the action of the various causes of error.

Substituting the probable error E for the mean error, the equation becomes

$$y = e^{-0.4769478^2 \frac{x^2}{E^2}}$$

If E_1, E_2, E_3, . . . are the errors due to a single cause we will have

$$E = \sqrt{E_1^2 + E_2^2 + E_3^2 + \dots}$$

For certain purposes, the curve may with sufficient approximation, be replaced by two right lines which intersect the axis of x at a distance of $+3H$ and $-3H$ from the origin and meet the axis of y in a common point.

A table of factors of probablity, calculated on the basis of this substitution, is practically equivalent to that derived from the curve, which is commonly adopted. The difference in the per cent. as given in the two tables never exceeds 2%. In figure 2a is drawn one branch of the curve of Laplace and for comparison with it the corresponding right line. Two other lines are also drawn, one heavy and the other light, to show the per cent. corresponding to the curve and right line respectively.

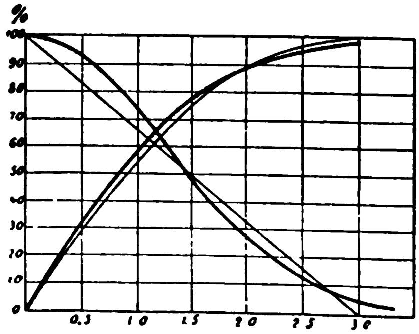

Fig. 2a.

This last method of representing the dispersion of the shots, although not exact, permits the solution of various problems with simplicity and clearness. We will adopt it then, for purposes of demonstration, reserving, for application, the more rigorous method, or at least that which is commonly admitted to be such, from the curve of Laplace.

Substituting the two right lines for the curve of probability, a triangle will represent the distribution of the shots on the hypothesis of a single piece, or many pieces supposed identical and pointed in the same manner, so that their trajectories are superimposed. If on the contrary the pieces fire with scaled elevations, to each piece or group of pieces a special triangle will correspond. The various triangles may not even be partially superimposed, according as the intervals between the elevations are greater or less than *6H*.

Let us suppose that we have *n* pieces or groups of pieces, with the elevations scaled at a certain interval ; the dispersion of the shots will be represented (figure 3a) by the triangles $a' b' c'$, a', $b'' c''$, . . . or, developing the portions of the triangles superimposed, by the polygon $a'mno$ . . . c^n. When the interval between the elevations is equal to *3H* (figure 4a) the dispersion of the shots is represented by a trapezium; there is then a central part of the path in which the shots are uniformly distributed.

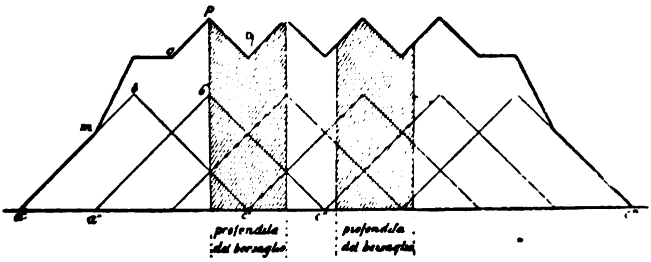

Fig. 3ª

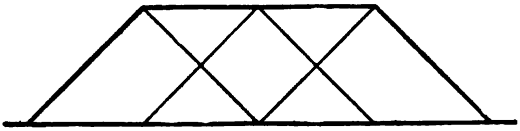

Fig. 4ª.

If the interval between the elevations is equal to the depth of the target, then, whatever its position, provided it is in the central part of the zone covered, it will always receive the same number of shots, (figure 3a); and if the zones covered by the individual elevations do not interpenetrate (figure 5a), the target will receive as many shots as it would have received from a centered fire from the pieces which fire with a single one of the adopted elevations.

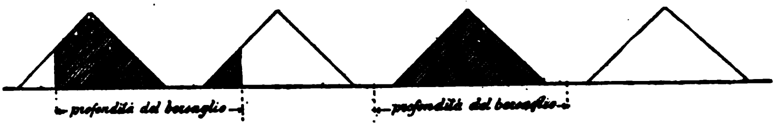

Fig. 5a.

The fire may be scaled in direction as in range. For our purpose it will suffice to consider the latter, which, moreover, is of the greater importance.

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The first objection which presents itself against scaled firing is that the probability of fire may thereby be diminished.

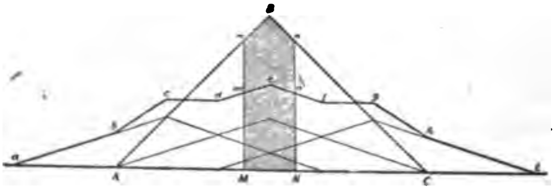

Fig. 6a

Let ABC (figure 6a) represent the dispersion of the shots of a battery which fires a united volley; let MN be the depth of the target. The relation $\frac{\text{area } MmBnN}{\text{area } ABC}$ will represent the proportion of the shots which will reach the target. Let us now assume that the same battery fires with different elevations, for example three, one corresponding to the distance calculated for the target, one greater and one less than this distance.

The triangle ABC is now replaced by the polygon $abc\ldots i$, and the proportion of the useful shots will be represented by the relation $\frac{\text{area } Mm'en'N}{\text{area } abc\ldots i}$ equals $\frac{\text{area } Mm'en'N}{\text{area } ABC}$. It is evident that this relation will always be less than that obtained from the united volley.

The same result would be obtained by assuming any other law for the dispersion of the shots.

Making the hypothesis, for example, that the vessel may by its own movement be found with equal probability in any position comprised between determinate limits, the dispersion of the shots would be represented, according to the case, either by a triangle or by a trapezium, and would thus still come under the preceding observation. A different result might be obtained in these two cases only :

1. When we admit that which seems to us inadmissible, namely, that the target has a greater probability of being at points more distant from its position as calculated previously.

2. When the center of firing instead of being at the center of the target is at a considerable distance from it.

For the battery of mortars adopted as a type in the United States, and referred to above, Lieutenant Honeycutt has demonstrated in the following simple manner, that it ought to give a per centage of useful shots less than would be obtained by pointing the pieces at the target independently of each other.

Let P_1, P_2, P_3 . . . P_{16} be the probability of fire for each mortar of the type battery when they are all pointed parallel to each other according to data which would only be true for a piece located at the center of the battery. Let Q_1, Q_2, Q_3 . . . Q_{16} be the probabilities corresponding to the same pieces respectively, when the data is the actual distance and true direction of each piece from the target. We will then have Q_1 greater than P_1, since Q_1 corresponds to a centered fire and P_1 to one which may be over or short or right or left of the target by a certain quantity. Similarly Q_2 is greater than P_2, Q_3 than P_3 . . . Q_{16} than P_{16} and consequently Q_1, Q_2, Q_3 . . . Q_{16} are greater than P_1, P^2, P_3 . . . $P^1{}_6$.

The employment of scaled elevations will always then, give a smaller probability of fire than that which may be obtained from a united volley. The importance of this disadvantage depends, however, on the manner in which these elevations are scaled. Any particular example will show however, that if certain limits are not exceeded, the probability of fire will diminish in a very small proportion.

If a battery of six pieces fire under conditions such that the probable range error of a single piece is 20m., and that of the center of impact of the volley is 120m., the depth of the 50% zone under the double hypothesis will be 243m. Against targets 49 and 100m. in depth we have with the united volleys 8.8 and 21.9% respectively, of the shots useful.

Scaling the fire so as to cover sections at intervals of 100m., we will obtain 8.1 and 19.7% respectively. Against the same targets scaling the fire so that half the shots are 40m. over and the other half 40m. short (as in the American battery), we get 8.6 and 21.4% respectively.

In these cases the difference between scaled firing and united volleys is, indeed, quite small.

In any case this will always be a disadvantage, however slight. But it is to be observed, the comparison between the two kinds of fire ought not to be made from this point of view alone nor on the hypothesis of an indefinitely prolonged fire. In practice the fire may be of short duration, when for various reasons, it will often be preferable to fire quickly and with a single shot at a target rather than to wait a long time in order to fire a volley which should be wholly useful. In such a case scaled firing may merit consideration.

It is here convenient to make a comparison between the two methods, not only on the hypothesis of a prolonged firing but also of volley for volley.

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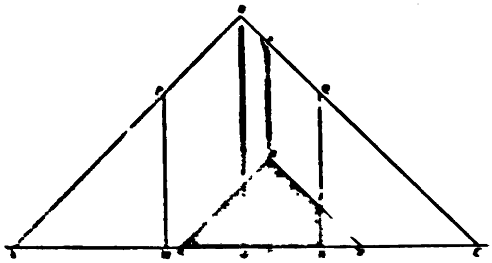

Fig 7a

Let ABC (figure 7a) represent the dispersion of the centers of the volleys calculated on a basis of probable error E_2 and $\alpha\beta\gamma$ the dispersion of the shots of a volley fired with a single elevation and calculated on a basis of a probable error E_1; let MN represent the depth of the target and let O be its center.

The centers of the individual volleys will take every possible position along AC, and to every position such as r, will correspond a frequency proportional to the ordinate rs. To every position will also correspond a special per cent. of the useful shots represented by the relation between the portion of the area of the triangle $\alpha\beta\gamma$ intercepted between MP and MQ and the area of the whole triangle. This relation may be zero for the positions of r most distant from O and will attain its maximum value when the center of the volley coincides with that of the target.

We may calculate the per cent. of the useful shots which belongs to the single volley in the various positions which its center takes and then trace a line whose ordinates will represent the per cent. of the useful shots and whose abcissas the distance between the center of the target and that of the volley.

A curve M of this kind is shown in plate *1* and was drawn under the hypothesis of a target 40m. in depth and of a probable error $E_1 = 20$.

In the same manner a curve may be traced under the hypothesis of fire scaled according to the dispositions which we wish to study. In this case, instead of a single curve, we will have as many as there are different elevations adopted. Adding therefore, the ordinates of the various curves corresponding to the same abcissa, we will obtain one whose ordinates represent the total per cent. of the useful shots obtainable with the whole volley when its center falls in a determinate position.

In plate *1* we have followed this method in tracing the curves a_1, a_2, a_3, and the curve A, corresponding to the the target and precision of fire already adopted for the curve M and to a fire scaled for sections at intervals of 100m.

A comparison of the curves M and A shows that for values of the abcissa of the center of the volley less than a certain limit $\pm\ Op$, the united volleys are more advantageous; the contrary is true for values of the abcissa greater than this limit. The abcissa $\pm\ Op$ of the point in which the curves A and M intersect corresponds to the point for which the scaled volleys are equivalent to the united ones.

To complete the comparison, we must know how many times the center of the volley falls farther or nearer to O than to p; or in general, how many times the abcissa will be less than a given quantity.

The probable error E_2 relative to the dispersion of the centers of the volleys being known, we can easily trace a curve which will give the required indications by taking for the ordinate corresponding to a given abcissa x, half the per cent. corresponding to the factor of probability $\frac{x}{E_2}$.

In this manner have been traced in plate 1 the curves R and S corresponding to values of E_2 equal to 60 and 120m. respectively.

It immediately appears from the curve of the dispersion A that the united firing is more advantageous until the center of the volley falls at a distance of 57m. from the center of the target; that is, 48 times out of 100 when $E_2 = 60$, and 26 times out of 100 when $E_2 = 120$m.

If the firing instead of being centered, is over or short by 100m. (curves R_1 and S_1) the scaled volley in the two cases considered will be more advantageous than the united one; that is, 73 and 78 times out of 100 respectively.

From this example it may be deduced that when the dispersion obtained by scaling the elevations bears a proper relation to the values of E_1 and E_2, the number of cases in which the scaled volley is more advantageous may be considerably greater than that of the united volley. In general it may be said that p will be by so much greater than q as E_1 becomes smaller and E_2 becomes greater.

This is about the same reasoning as that followed by the Board which in the United States defended the typical battery.

It seems nevertheless, that the comparison between the two methods was made in vague and inexact terms, so that the demonstrations in favor of scaled firing are not sufficiently rigorous to convince us. By scaling the elevations we take a certain proportion of the useful shots from the more restricted central part where the target has little likelihood of being found, in order to scatter them over a more ample external space where, in fact, this likelihood is greater. But it is not very clear to what extent the gain of the useful shots in the part more distant from the center compensates the loss sustained in the central part. Referring to the example of plate 1 we see how, when the center of the volley falls at a certain distance from the target, the per cent. of the useful shots is certainly greater with the scaled volley than with the united volley; but the difference diminishes so rapidly, as to leave doubt, in truth, whether the scaled volley gives a sensible advantage. In any case the measure of this advantage is lacking.

To obtain a more rigorous and determinate comparison it will be necessary to compare the probability of obtaining in the two systems, at least one useful shot from each volley; a criterion which Lieutenant Calichiopula has followed and which Lieutenant Honeycutt of the United States has also proposed.

Denoting by Q and Q_1 the probabilities of obtaining at least one useful shot with the united and scaled volleys respectively, it is easily seen that Q will be greater or less than Q_1 according to the values of E_1 and E_2.

Let us consider the two cases in which E_1 and E_2 are successively zero.

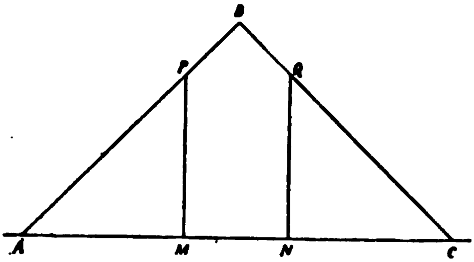

Fig. 8a

Let ABC (figure 8a) represent the dispersion of the centers of the volleys when the probable error is E_2, and let MN be the depth of the target. If $E_1 = O$, firing with united volleys, those whose centers fall between M and N will have all their shots useful, but they will also be the only ones to have useful shots. Firing instead, with volleys suitably scaled we will have useful shots not only from those whose centers fall between M and N, but also from a part of those whose centers fall without: in this case Q_1 is greater than Q.

Let us now assume $E_2 = O$, and let ABC represent the dispersion of the shots of a single volley for a particular value of E_1. Let n be the number of the shots of one volley. Each volley will have a certain proportion S of useful shots.

The probability of having at least one useful shot in one volley will be

$$Q = 1 - (1 - S)^n.$$

By scaling the volley this is divided into so many groups, to each of which belongs a certain probability of fire. Let S_1, S_2, . . . represent these various probabilities, one of which may be equal to S, whilst the others are all less. We will then have

$$Q = 1 - (1 - S_1)(1 - S_2) \dots$$

in this case Q_1 is less than Q.

It may be shown with any example that within the limits of ordinary conditions, the scaled volley gives a greater probability of having at least one useful shot.

The method of calculation to be followed in making this comparison is based on the principle of total probabilities which we believe proper to reproduce here.

"If an event E may be attributed to various causes, c_1, c_2, c_3 . . . , which mutually exclude each other, and if we designate by p_1, p_2, p_3 . . . the probability that these causes act; by q_1, q_2, q_3 . . . the probability of the event E when the causes do act, the probability P of the event E will be given by the formula

$$P = p_1 q_1 + p_2 q_2 + p_3 q_3 + \dots \text{''}$$

Let us assume a united volley of n shots whose center falls in r (figure 7a) at a distance x from O; such a volley will give a certain proportion p of the shots as useful, the calculation being based on the value of E. The probability that there will be at least one useful shot will be given by the formula

$$q = 1 - (1 - p)^n.$$

Similarly the number of volleys whose centers will fall in an element of a depth dx near r will be $\frac{y\,dx}{\text{area } ABC}$, y being the ordinate rs. The product $\frac{q\,y\,dx}{\text{area } ABC}$ corresponds to that of $p\ q$ which appears in the enunciation of the principle of total probability. An analogous reasoning may be made for any other position in which the center of a volley may fall, so that the total probability of having at least one shot on the target will be *

$$Q = \Sigma \frac{q\,y\,dx}{\text{area } ABC}.$$

If instead of being united the volley is scaled, the probability of having with it at least one useful shot when it falls in a given position is

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* Lieutenant Calichiopula adopts instead, the value which would be obtained from the formula

$$Q = 1 - (1 - p)^n$$

in which p is the per cent. of the useful shots which would be obtained when the firing is subject to a probable error $E = \sqrt{E_1^2 + E_2^2}$.

This formula corresponds to the case in which each of the n pieces is pointed with its own elevation, calculated on the basis of an indepedent range finder operation for each piece. This is, of course, contrary to the data of the problem and should lead to inaccurate results. This fact is easily seen as follows:

If n is sufficiently large, with Lieutenant Calichopulo's method Q may be as near unity as may be desired, and the conclusion reached that there is almost a certainty of obtaining at least one useful shot, whatever may be the values of E_1 and E_2.

If, instead, $E_1 = 0$, we see that the volleys whose centers are comprised between M and N (figure 8a) will have their shots useful, but they will also be the only ones to have useful shots; we therefore have

$$Q = \frac{\text{area } MPQN}{\text{area } ABC},$$

a relation which may differ considerably from unity.

The method adopted for calculating the probability of having at least one useful shot in the case of scaled firing seems also to be rather inaccurate.

$$q_1 = 1 - (1 - p_1)(1 - p_2)(1 - p_3) \dots$$

$p_1, p_2, p_3 \dots$ being the probabilities of fire of the single groups into which the volley has been divided. The complete probability of having at least one useful shot upon the target is still

$$Q = \Sigma \frac{q_1 y dx}{\text{area } ABC}.$$

To obtain the values of

$$\Sigma \frac{q y dx}{\text{area } ABC}$$

and

$$\Sigma \frac{q_1 y dx}{\text{area } ABC}$$

we proceed as follows:

We trace the curve of the dispersion of the centers of the volleys (curve α) (figure 9a) by means of the equation

$$y = e^{-0.476^2 \frac{x^2}{E_2^2}}$$

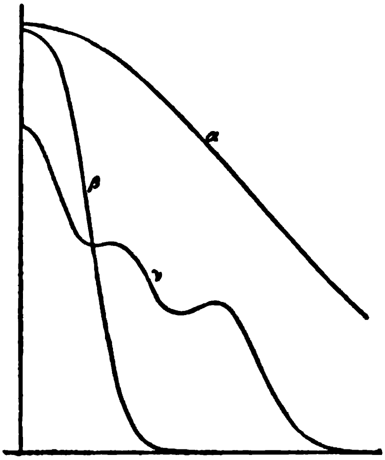

Fig 9a.

For different valnes of x we calculate q and p and then qy and q_1y. Taking these last two values as ordinates corresponding to the abcissa x we trace the curves (β) and (γ). The areas comprised between the above curves and the co-ordinate axis may then be calculated by the method of quadrature. The relations

$$\frac{\text{area } (\beta)}{\text{area } (\alpha)}, \quad \frac{\text{area } (\gamma)}{\text{area } (\alpha)}$$

will represent the probability of having at least one useful shot by firing respectively with a united and a scaled volley.*

If through some particular circumstances the fire instead of being centered, is over or short by some definite quantity as *m*, or if, instead of following the law of accidental errors, the dispersion follows some other law represented by the equation $y = f(x)$, the proceedings will still be the same. In the first case the curve (a) would be traced with its axis at a distance *m* from the center of the target, and in the second case instead of drawing the curve (a) we would draw that represented by the equation $y = f(x)$. The ordinates of the curves (b) and (c) could then be calculated by taking the value of *y* which in the curves already traced correspond to the various abscissas. This is the method followed in calculating the curve traced in plate 2.

The curve (a) corresponds to the equation

$$y = e^{-\rho^2 \frac{x^2}{E_1^2}}$$

in which $E_1 = 12$cm.

The curves (b) and (c) correspond to united volleys of six pieces, E_1 being equal to 20cm., and the depth of the target being 40 and 100cm. respectively. By means of these curves we have found that in the two cases the probabilities of having at least one shot are 24 and 57 per cent. respectively.

The curves (d) and (e) correspond to scaled volleys of six pieces, two of which are pointed at the center of the target, two at a point 10cm. over, and two at a point 10cm. short, the other data being the same as for the curves (b) and (c). The probability of having at least one useful shot in this case is 37 per cent. for the 40cm target and 63 per cent. for the 100cm target.

* * * * * * *

The results attainable with scaled firing depend, naturally, on the manner and on the conditions under which it was executed. We do not know whether, or even to what point, it would be possible to determine, theoretically, precise rules based on such arguments. This is a study which we have thought of attempting, desiring to limit ourselves for the present, to the preliminaries of the question. Further, by multiplying the examples and proofs we may be able to obtain some useful data.

In the appendix have been placed A and B, which may be useful to those who intend making researches of this kind. Table

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* The [illegible] means of calculating the probability [illegible] we have [illegible] it has saved us from a theoretical argument of a grave character.

A is only a table of factors of probability, more exact than those generally employed. Table B contains the values of the function

$$y = e,^{\frac{\quad}{-0.476^2}x^2}$$

and permits, therefore, of tracing the curve of probability, taking the probable error as a unit of the abcissa.

Some simple observations and various experiments which we have made, permit us in the meantime, to determine some general criterion.

The value of Q_1, the probability of having at least one useful shot with a scaled volley, depends upon the sum of a number of terms and is completely expressed by the following:

$$\{ 1 - (1 - p_1)(1 - p_2) \ldots \} y.$$

If the firing is scaled between limits which are too restricted with reference to the value of E_2, the first terms of the above expression will be relatively great, but the progression will diminish rapidly with a reduction in the value of Q_1. If the firing is too broadly scaled the first terms in the above expression will become small, thus causing the first factor of the product which they enter to be small. This diminution is not sufficiently compensated by the increase in the value of the last term since this also will be small with diminished value of y.

In order then, to obtain the maximum probability of fire it is necessary to scale the firing in accordance with a compromise between opposing requirements, a compromise which will vary according to the conditions of the fire.

In general the scaling of the fire may be greater, the greater the value of E_2 and the less the value of E_1, and the greater the number of piece and the greater the dimensions of the target.*

It is however evident, that the more the scaling of the fire is broadened, the greater will be the the diminution in the per cent. of the useful shots as compared with that which would be obtained with united firing.

The few examples employed, others which we have calculated, but which it has seemed useful to reproduce here, will show that by suitably scaling the elevations, the probability of having in one volley at least one useful shot is greater than that which would be obtained in united firing. The difference in many cases will not be such as to produce appreciable effects, but under some special conditions it may be sufficiently great to give a certain advantage in favor of scaled firing.

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* It was calculated by Professor Wuich and is employed by Bertrand in his Calcul des probabilitées.

In general we will have the following cases:

1. When the movements of the target are such as to permit the supposition that it has a great probability of being at points more distant than its previously calculated positions. We have already said that this hypothesis is scarcely admissible; whenever its existence can be verified scaled firing may be experimentally employed. Indeed, by modifying the curve (*a*) (figure 9a) so that the greater values of y correspond to abcissas for which q is already inappreciable while q_1 still preserves an appreciable value, Q_1 should be quite advantageous as compared with Q. In this case, moreover, by scaling the elevations we do not diminish and sometimes we increase the per cent. of the useful shots in all of the firing.

2. When we presume that the firing is not centered, which may happen in the first volley every time that we find strong causes of deviation in action. The explanation is analogous to that of the preceding case, as are also the observations relative to the per cent. of the useful shots.

Moreover, scaled elevations now admit of another advantage. Some of the causes of deviation, the wind especially, may produce strong deviations which may attain to some hundreds of meters. We do not adopt instruments nor calculations for reducing this deviation until after the first shot.

A battery commander having to begin firing when there is a strong wind will certainly attempt a correction, estimated by the eye and which will generally be but approximate. By groping in this manner we waste time and projectiles; three or four minutes of time and four, six or more projectiles per volley; indeed, several volleys may be necessary before we succeed in attaining an approximation sufficiently accurate to enable us to place some shots upon the target. A volley fired with elevations (or deviations, according to the case) scaled between limits which comprise the deviations would abridge this preliminary adjustment, by reducing to a minimum the consumption of time and shots.

3. When we realize all or some of the following conditions: The value of E_2 quite large in comparison with that of E_1; target very deep (or very broad); a large number of available pieces. This will be easily understood when we reflect on the manner in which q, q_1, and y vary. In addition to the examples already cited we will limit ourselves to citing one other. E_1 being as before 20m., and $E_2 = 120$m. and the depth of the target 100m. we obtain for a battery of 10 pieces $Q = 0.40$;

scaling, now, the fire for sections at intervals of 100m. we find $Q_1 = 0.83$.

In this last case, however, the scaled firing is advantageous only when the firing is reduced to one or to but a few volleys. It ceases to be so when the number of volleys is increased, or when fired from different batteries.

With united firing, the useful shots are unequally distributed among the various volleys; they are even grouped in a few of these; with scaled firing the distribution is more nearly uniform. If the volleys to be fired are very restricted in number, there will be little probability of obtaining one, with the united firing, which will give all or almost all of its shots useful. In that case it may be advantageous to adhere to scaled firing with which there is a greater probability of having at once a volley which gives at least one useful shot, provided, be it well understood, the power of this shot is such as to produce by itself a sensible effect. This advantage disappears when the number of volleys is increased and it is immaterial whether the volleys proceed from the same or from different batteries. The number of useful shots obtained with the two methods remains the same, in fact, it may even be somewhat greater with united firing. It is of little importance whether the useful shots are grouped in one or in a few volleys or are divided equally among all; even different projectiles striking the target together produce a greater moral effect than successive hits. There is therefore, no reason for accepting the inconveniences, the difficulties and the complications inherent in scaled firing, difficulties and complications which may be variously estimated, which will not be insuperable, but which undeniably exist and which in practice must result in delays, perplexities and errors.

* * * * * * *

In conclusion, we will consider the case of scaled firing by batteries united in group, instead of by pieces in the same battery.

The scaling may now be executed in two ways:

1. On the basis of the data derived from a central station by a single operation of the range finder; the firing will thus be executed simultaneously by the whole battery.

2. On the basis of the data derived from each battery independently; so that having, for example, three batteries, one only points with the data which it has obtained; of the other two, one increases and the other diminishes it by a certain quantity.

We must first of all observe that by treating of a certain number of batteries which may derived the data of their fire independently of each other, the probability of having at least one useful shot is calculated in a different manner from that adopted for a single battery.

Let us consider three batteries which for simplicitly we will suppose under identical conditions with respect to the target. Let K be the probability of having at least one useful shot from a volley for each battery. The same probability for the entire group will be

$$Q = 1 - (1 - K)^3$$

a probability which ought generally to be greater than that that would be obtained from firing the three batteries with the same data. Thus we have found that six pieces firing a simultaneous volley with the same data and under the same conditions ($E_1 = 20$, $E_2 = 120$, and depth of target = 40m.) has a probability of 24 per cent. of obtaining one useful shot. If the 6 pieces be now divided into three sections of two pieces each and volleys be fired from the three sections independently of each other, the probability above becomes 37 per cent.

If we now imagine a group of batteries that scale the firing in accordance with the first two methods indicated, laying aside the evident difficulties and inconveniences which are likely to be encountered, we may repeat what has been stated in the case of a single battery already studied. While, therefore, the advantage of the greater probability of having one useful shot, when compared with a fire executed independently by each battery, increases on the one hand by the great number of pieces available, it must, on the other hand, diminish for the reasons noted above.

Finally, if the fire from the three batteries is scaled according to the second method, it immediately appears that the probability of having at least one useful shot is diminished, when compared with the fire executed by the batteries independently. In this last case, in fact, such probability is represented by

$$Q = 1 - (1 - K)^3.$$

and for scaled firing it will be instead

$$Q_1 = 1 - (1 - K)(1 - K)^2,$$

K_1 in this expression being less than K, Q_1 will likewise be less than Q.

TABLE A.*

FACTORS OF PROBABILITY.

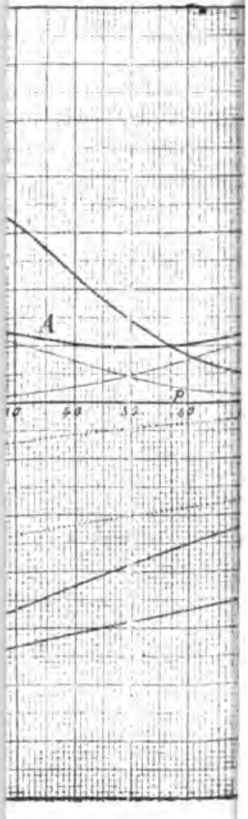
f	*P*	Diff.	*f*	*P*	Diff.	*f*	*P*	Diff.	*f*	*P*	Diff.
0.00	0.00	54	0.25	13.39	53	0.50	26.41	50	0.75	38.70	48
0.01	0.54	54	0.26	13.92	53	0.51	26.91	51	0.76	39.18	47
0.02	1.08	53	0.27	14.45	53	0.52	27.42	51	0.77	39.65	47
0.03	1.61	54	0.28	14.98	53	0.53	27.93	50	0.78	40.12	47
0.04	2.15	54	0.29	15.51	53	0.54	28.43	50	0.79	40.59	46
0.05	2.69	54	0.30	16.04	52	0.55	28.93	51	0.80	41.05	47
0.06	3.23	54	0.31	16.56	53	0.56	29.44	50	0.81	41.52	46
0.07	3.77	53	0.32	17.09	52	0.57	29.94	50	0.82	41.98	46
0.08	4.30	54	0.33	17.61	53	0.58	30.44	49	0.83	42.44	46
0.09	4.84	54	0.34	18.14	52	0.59	30.93	50	0.84	42.90	46
0.10	5.38	53	0.35	18.66	53	0.60	31.43	49	0.85	43.36	45
0.11	5.91	54	0.36	19.19	52	0.61	31.92	50	0.86	43.81	46
0.12	6.45	54	0.37	19.71	52	0.62	32.42	49	0.87	44.27	45
0.13	6.99	53	0.38	20.23	52	0.63	32.91	49	0.88	44.72	45
0.14	7.52	54	0.39	20.75	52	0.64	33.40	49	0.89	45.17	45
0.15	8.06	53	0.40	21.27	52	0.65	33.89	49	0.90	45.62	44
0.16	8.59	54	0.41	21.79	51	0.66	34.38	49	0.91	46.06	45
0.17	9.13	53	0.42	22.30	52	0.67	34.87	48	0.92	46.51	44
0.18	9.66	54	0.43	22.82	52	0.68	35.35	49	0.93	46.95	44
0.19	10.20	53	0.44	23.34	51	0.69	35.84	48	0.94	47.39	44
0.20	10.73	53	0.45	23.85	51	0.70	36.32	48	0.95	47.83	44
0.21	11.26	54	0.46	24.36	52	0.71	36.80	48	0.96	48.27	44
0.22	11.80	53	0.47	24.88	51	0.72	37.28	47	0.97	48.71	43
0.23	12.33	53	0.48	25.39	51	0.73	37.75	48	0.98	49.14	43
0.24	12.86	53	0.49	25.90	51	0.74	38.23	47	0.99	49.57	43

---

* The column headed Diff. contains the variations of P in hundredths corresponding to variations of one one-hundreth in f.

TABLE A.

f	*P*	Diff.	*f*	*P*	Diff	*f*	*P*	Diff.	*f*	*P*	Diff.
1.00	50.00	42	1.52	69.47	31	2.10	84.33	19	3.40	97.82	4
1.02	50.85	42	1.54	70.10	31	2.15	85.30	18	3.45	98.00	4
1.04	51.70	42	1.56	70.72	31	2.20	86.22	17	3.50	98.18	3
1.06	52.54	41	1.58	71.34	30	2.25	87.09	17	3.55	98.34	3
1.08	53.37	41	1.60	71.95	30	2.30	87.92	16	3.60	98.48	3
1.10	54.19	40	1.62	72.55	29	2.35	88.70	15	3.65	98.62	2
1.12	55.00	40	1.64	73.13	29	2.40	89.45	14	3.70	98.74	2
1.14	55.81	39	1.66	73.71	28	2.45	90.16	13	3.75	98.86	2
1.16	56.60	39	1.68	74.28	28	2.50	90.82	13	3.80	98.96	2
1.18	57.39	39	1.70	74.85	27	2.55	91.46	12	3.85	99.06	2
1.20	58.17	38	1.72	75.40	27	2.60	92.05	11	3.90	99.15	2
1.22	58.94	38	1.74	75.94	27	2.65	92.61	11	3.95	99.23	1
1.24	59.70	38	1.76	76.48	26	2.70	93.14	10	4.00	99.30	1
1.26	60.46	37	1.78	77.01	26	2.75	93.64	9	4.10	97.43	1.1
1.28	61.21	36	1.80	77.53	25	2.80	94.11	9	4.20	99.54	0.9
1.30	61.94	36	1.82	78.04	25	2.85	94.54	8	4.30	99.63	0.7
1.32	62.67	36	1.84	78.54	25	2.90	94.95	8	4.40	99.70	0.6
1.34	63.39	35	1.86	79.04	24	2.95	95.34	7	4.50	99.76	0.5
1.36	64.10	35	1.88	79.52	24	3.00	95.70	7	4.60	99.81	0.4
1.38	64.80	34	1.90	80.00	23	3.05	96.03	6	4.70	99.85	0.3
1.40	65.49	34	1.92	80.47	23	3.10	96.35	6	4.80	99.88	0.3
1.42	66.18	34	1.94	80.93	22	3.15	96.64	5	4.90	99.91	0.2
1.44	66.86	33	1.96	81.38	22	3.20	96.91	5	5.00	99.93	
1.46	67.53	32	1.98	81.83	22	3.25	97.16	5			
1.48	68.18	32	2.00	82.27	21	3.30	97.50	4			
1.50	68.83	32	2.05	83.32	20	3.35	97.62	4			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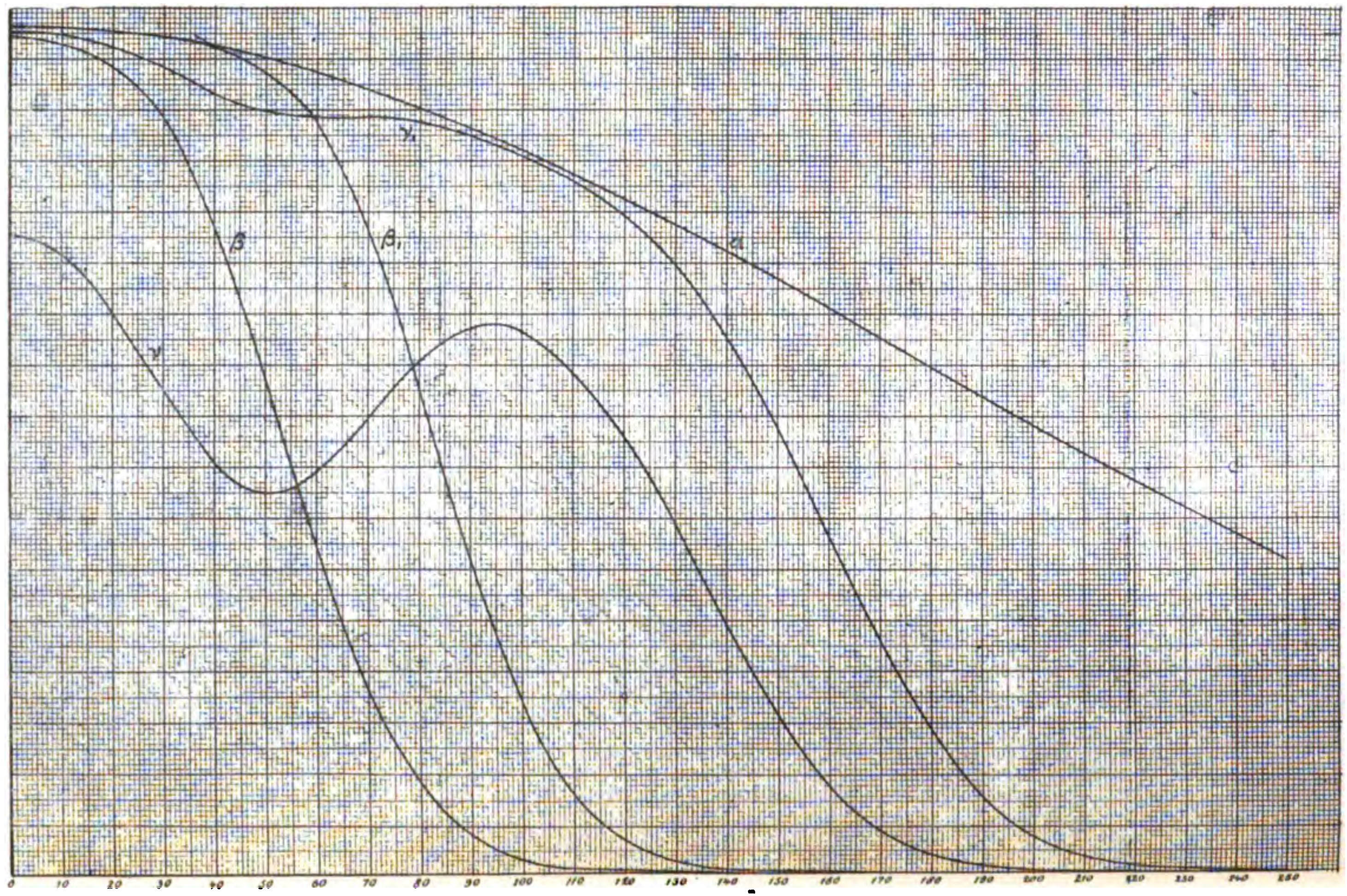
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150
160
170
180
190
200
210
220
230
240
250

PLATE II.

TABLE B.

VALUES OF THE FUNCTION $y = e^{-\overline{0.4769478}^2 x^2}$

x	y	x	y	x	y	x	y
0.0	1.0000	1.3	0.6808	2.6	0.2149	3.9	0.0314
0.1	0.9977	1.4	0.6403	2.7	0.1905	4.0	0.0263
0.2	0.9909	1.5	0.5994	2.8	0.1681	4.1	0.0218
0.3	0.9797	1.6	0.5586	2.9	0.1476	4.2	0.0180
0.4	0.9642	1.7	0.5182	3.0	0.1291	4.3	0.0149
0.5	0.9447	1.8	0.4785	3.1	0.1124	4.4	0.0122
0.6	0.9213	1.9	0.4399	3.2	0.0974	4.5	0.0100
0.7	0.8945	2.0	0.4026	3.3	0.0840	4.6	0.0081
0.8	0.8645	2.1	0.3659	3.4	0.0721	4.7	0.0066
0.9	0.8317	2.2	0.3326	3.5	0.0616	4.8	0.0053
1.0	0.7965	2.3	0.3002	3.6	0.0524	4.9	0.0042
1.1	0.7594	2.4	0.2698	3.7	0.0444	5.0	0.0034
1.2	0.7207	2.5	0.2419	3.8	0.0374		

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[Translated by First Lieutenant F. E. HARRIS, 3d Artillery.]

THE IRREDUCIBLE CASE OF THE CUBIC EQUATION.

The most general form of the equation of the third degree is

$$x^3 + Ax^2 + Bx + C = 0.$$

In this, place

$$x = y - \frac{A}{3}.$$

This gives the following equation, involving y:

$$y^3 + py + q = 0, \text{ where}$$

$$p = \frac{3B\,A^2}{3},$$

and

$$q = \frac{2A^3}{27} - \frac{AB}{3} + C.$$

Cardan's rule applies to the equation $y^3 + py + q = 0$, and the result is satisfactorily obtainable where

$$\frac{q^2}{4} + \frac{p^3}{27} > \text{ or } = 0.$$

This inequality is satisfied wherever p is a positive qualty, and also where p is both negative and numerically less than or equal to

$$\frac{3}{2}\sqrt[3]{2q^2}.$$

If Cardan's rule fails, we have the "Irreducible Case," so called because it involves roots of imaginary quantities which we do not know how to extract.

For the sake of greater clearness we replace p (which, in irreducible cases, has been shown to be essentially negative) by $-p'$. Then

$$y^3 - p'y + q = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Now place $\qquad y = z\sqrt{p'}.$

Then by substitution in equation (1),

$$z^3 - z + \frac{q}{p'\sqrt{p'}} = 0.$$

Place $\qquad \dfrac{q}{p'\sqrt{p'}} = q'$; then,

$$z^3 - z + q' = 0.$$

Enter the table (accompanying this) with the value of q' as an argument, and by interpolation find z. The sign of z is the opposite of that of q'.

Then

$$x = y - \frac{A}{3} z \sqrt{p'} - \frac{A}{3}.$$

This is the outline of the *use* of the method. An example follows, and then follows the method by which the preceding was deduced.

EXAMPLE.

$$x^3 - 3x^2 - 5x + 1 = o.$$

Here,

$$p = \frac{3B - A^2}{3} = -8,$$

and

$$q = \frac{2A^3}{27} - \frac{AB}{3} + C = +8,$$

$$\frac{q^2}{4} + \frac{p^3}{27} = -2\frac{26}{27}, \text{ which } < o, \text{ and}$$

Cardan's rule is inapplicable.

Place

$$y = x + \frac{A}{3} = x + 1.$$

Then

$$y^3 - 8y + 8 = o.$$

Place

$$y = z\sqrt{p'} - z\sqrt{8}.$$

Then

$$z^3 - z + \frac{1}{4}\sqrt{2} = o,$$

or

$$z^3 - z + 0.35355355 = o.$$

Now refer to the table, and we find that

for $z = 1.144$ . . . . $q' = 0.353194$;
" $z = 1.145$ . . . . $q' = 0.356124$.

Finding by interpolation from this the value of z corresponding to $q' = 0.35355355$, we have

$$z = 1.144122,$$

and

$$y = z\sqrt{8} = -3.236069.$$

Hence

$$x = y - 1 = -4.236069.$$

Substituting this in our original equation, we have

$$x^3 = -75.98 \quad = -75.98$$

$$\left.\begin{array}{l} +3x^2 = +53.80 \\ -5x = +21.18 \\ +1 \ \ = +\ \ 1.00 \end{array}\right\} = +75.98$$

$$x^3 + 3x^2 - 5x + 1 = +75.98 - 75.98 = 0.$$

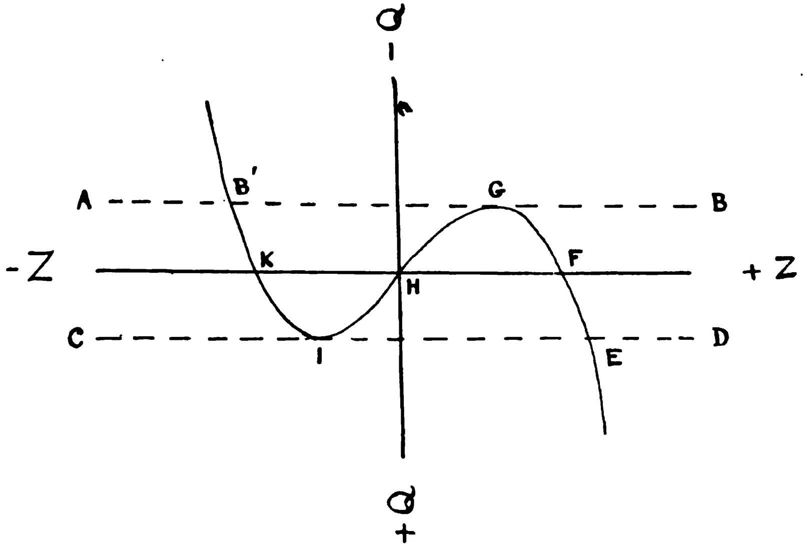
This root, then, satisfies the equation. The other two may be readily obtained, as can readily be done when one root is known. This is the method followed.

The *reasons* follow :

The equation being in the form

$$z^3 - z + q' = 0,$$

we may, by assigning "consecutive" values to the arbitrary constant q', obtain corresponding values for z, and, plotting the result, we obtain the curve whose ordinate is q', which is treated as a variable.



Now examine the curve for maximum and minimum points. From

$$z^3 - z + q' = 0,$$

we have, by differentiation,

$$\frac{dq'}{dz} = 3z^2 = 1;$$

and for a maximum or minimum point

$$\frac{dq'}{dz} = 0 = 3z^2 - 1;$$

whence

$$z = \pm \frac{1}{3} \sqrt{3}.$$

and the corresponding values of q are

$$q = \pm \frac{2}{9} \sqrt{3}.$$

Draw the lines $A\,B$ and $C\,D$ parallel to the axis of z. Their equations are respectively

$$q' = -\frac{2}{9}\sqrt{3}\,.$$

$$q' = +\frac{2}{9}\sqrt{3}\,.$$

Now revert to the condition of applicability of Cardan's rule. In this case, since $p' = 1$

$$\frac{{}'^{2}}{4} - \frac{1}{27} > \text{or} = 0.$$

Hence

$$\frac{q'^{2}}{4} > \text{or} = \frac{1}{27}.$$

This gives q' a value greater numerically than, or equal numerically to $\pm \frac{2}{9} \sqrt{3}\,.$

Now, in our curve, the division between solubility and insolubility by Cardan's rule is along the lines $A\,B$ and $C\,D$, whose equations are, respectively,

$$q' = -\frac{2}{9}\sqrt{3}\,,$$

and

$$q' = +\frac{2}{9}\sqrt{3}\,.$$

It is interesting to note that for values of q' numerically greater than $\frac{2}{9} \sqrt{3}$ there is only one real value of z, while for values of q' numerically less than $\frac{2}{9} \sqrt{3}$ there are three real values of z, (this being all in reference to the curve), and at the same time to remember that Cardan's rule applies only to equations having one real root and two imaginary roots.

Hence we confine ourselves to the portion of the curve between the lines $A\,B$ and $C\,D$: the "Irreducible Case." Observing the form of the curve, we see that by selecting any one of the six arcs, *E F*, *F G*, *G H*, *H I*, *I K*, *K B'*, z may be given values in the selected segment, at small regular intervals, from which corresponding values of q' may be obtained, since $z^3 - z = -q'$. If a sufficient number of such values be obtained, a table will result, from which, either z or q' being given, the other may be found by interpolation to any desired degree of accuracy, depending upon the magnitude of the interval between successive values of z.

I have selected the arc *K B* because in that portion of the curve q' increases more rapidly than z, and for any change in q' there is a far smaller change in z. This is an advantage, q' being the argument with which the table is generally entered, and z the value to be found.

The sign of q' does not affect the validity of the table numerically, since by substituting $-z$ for $+z$ in the equation $z^3 - z + q' = o$, we obtain $z^3 - z - q' = o$, and we find that where q' is negative z is positive, and *vice versa*, the second member of the equation being *zero*. Hence, whatever the sign of q', provided its value lies between o and $\pm \frac{2}{9}\sqrt{3}$, the table above indicated gives one value of z' corresponding to the value of q', from which the two remaining roots may readily be found.

Having found from the table a value of z lying on *K B'*, taking care to prefix the proper sign, the two other values may be found from a quadratic equation, or similar tables may be constructed for the segments *H G* and *G F*, the two roots so obtained having their numerical values determined by those tables and the signs being the same as that of q', the second member of the equation being zero.

The table attached includes values of z from 1.000 to 1.160, giving quite accurate results. The accuracy may be increased by decreasing the intervals between values of z to any desired extent. This table will solve any cubic equation with real coefficient that is "irreducible." In all other cases apply Cardan's rule, which is (see *Todhunter's Theory of Equations*):

Given the equation

$$x^3 - p\,x + q = o,$$

$$x = \sqrt[3]{-\frac{q}{2} + \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}} + \sqrt[3]{-\frac{q}{2} - \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}},$$

Table for the Solution of the Irreducible Cases of the Cubic Equation.

z.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
1.00	.00000	.002003	.004012	.006027	.008048	.010075	.012108	.014147	.016193	.018244
1.01	.020301	.022364	.024434	.026509	.028591	.030678	.032772	.034872	.036978	.039090
1.02	.041208	.043332	.045463	.047600	.049743	.051892	.054047	.056208	.058375	.060548
1.03	.062727	.064913	.067105	.069303	.071507	.073718	.075935	.078158	.080387	.082622
1.04	.084864	.087112	.089366	.091626	.093892	.096165	.098444	.100730	.103022	.105321
1.05	.107625	.109936	.112251	.114572	.116900	.119235	.121577	.123926	.126282	.128645
1.06	.131016	.133390	.135771	.138159	.140553	.142953	.145359	.147771	.150189	.152613
1.07	.155043	.157481	.159926	.162378	.164836	.167300	.169770	.172246	.174728	.177217
1.08	.179712	.182214	.184723	.187238	.189760	.192288	.194823	.197364	.199912	.202467
1.09	.205029	.207597	.210171	.212758	.215338	.217932	.220533	.223140	.225753	.228373
1.10	.231000	.233633	.236273	.238920	.241573	.244233	.246900	.249573	.232252	.254938
1.11	.257631	.260331	.263038	.265751	.268471	.271197	.272930	.276670	.279416	.282169
1.12	.284928	.287695	.290469	.293249	.296036	.298830	.301630	.304436	.307250	.310070
1.13	.312897	.315731	.318572	.321420	.324275	.327137	.330006	.332881	.335762	.338650
1.14	.341544	.344446	.347355	.350271	.353194	.356124	.359061	.362004	.364954	.367911
1.15	.370875	.373846	.376824	.379809	.382801	.385800	.388806	.391818	.394837	.397863
1.16	.400896									

NOTE.—First column contains values of *z*. Nos. 0, 1, 2, 3, 4, 5, 6, etc., at heads of columns belong to *z*, carrying its value to thousandths.

All columns but the first contain values of *q*. Arrangement of table like that of a table of logarithms.

because in the "reducible" cases, the operations indicated in Cardan's rule *can* be performed.

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2d Lieutenant, 1st Artillery.

SIGNAL CORPS
U.S. ARMY.

SIGNAL CORPS
U.S. ARMY

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

Electric Vehicles for the Army.

For the first time in the history of the United States a contract has been placed and executed for electric automobiles, three in number, designed for the Signal Corps of the United States Army, expressly under the specifications of the chief signal officer.

Two wagons are made like that shown in Fig. 1 and are designed to carry the Signal Corps' various instruments and paraphernalia, and one wagon (Fig. 2) is designed for the officers of the Signal Corps to ride in.

The equipment of the first-mentioned wagons includes 40 cells of storage battery of sufficient capactiy, it is said, to run the vehicles 30 miles on one charge of the batteries when carrying 1,500 pounds of transportation load. The motor equipment consists of two 3½ horse-power motors, one attached directly and independently to each rear wheel. They are so wound and designed that they can be worked on grades and bad roads as high as six horse-power each, which would mean a maximum horse-power capacity of 12 horse-power for each wagon, the batteries being of sufficient size to work at that point for temporary work.

The maximum speed of the vehicle is 10 miles an hour. A notable feature is the entire absence of anything like bicycle construction. Every piece of ironwork in the vehicle, from start to finish, was hand-forged. The wheels were especially designed and made with steel hubs, the inside of which form receptacles for the ball bearings, as it was found that iron hubs were not adequate to this work. Solid hard-rubber tires, 2½ inches in diameter, have been used.

While similar in appearance to delivery wagons, the interior arrangement is constructed after army specifications. The space is accessible from both rear and front, and doors are supplied, which, when the wagons are not in use, lock everything securely in their interior.

These army wagons are finished in olive green in both body and gear, without any form of ornament or striping, being painted as near the color of grass and foliage as possible, so that they will not be conspicuous to the enemy in the field. They are fitted up with electric lights in the side lanterns, and, in the larger vehicles, in the interior also, and it is understood that later a new form of searchlight will be added to the equipment, for use as occasion may require.

The wagons were turned out complete from the shops of the Woods Motor Vehicle Company of Chicago, which was awarded the contract by the government.

—*Western Electrician*, October 14, 1899.

A New Method of Moulding and Pressing Guncotton.

A new method of forming and compressing guncotton has just been perfected at the Stowmarket factory of the New Explosives Co., Ltd., and it is now possible to produce charges of compressed guncotton mechanically true, and of a size and weight hitherto unapproached. At the same time, the new process ensures a perfectly uniform density throughout the block, and permits any required density from 1.4 downwards being attained.

By the new process it is also possible to regulate with exactitude the percentage of moisture, and to ensure its uniform distribution. The maximum percentage of moisture depends, of course, upon the density. By the new process any required percentage from this maximum downwards can be exactly obtained.

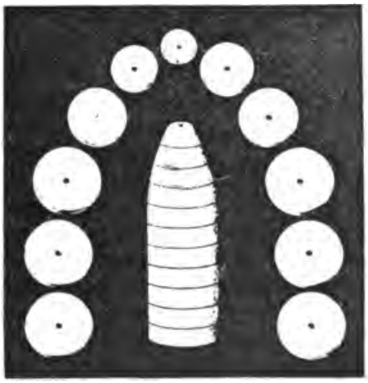


Fig. 1.—Illustration of a Guncotton Bursting Charge for an 8-inch Deck-piercing Shell, built up in separate discs and turned in lathe to shape—the component discs being shown around an assembled charge.

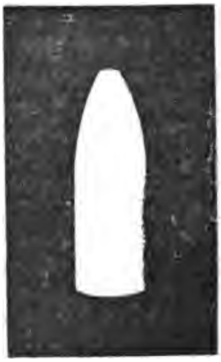


Fig. 2.—Illustration of a Guncotton Bursting Charge for an 8-inch Deck-piercing Shell as it is shaped, moulded and pressed in one solid block by the new process.

By the methods hitherto employed of compressing guncotten, blocks of a greater thickness than two inches, or of a greater weight than about 8 to 9 pounds cannot be made, but with the new process blocks of any shape, size, thickness and weight that are likely to be required, can be made readily and safely.

With the old method of work certain practical difficulties have prevented the direct formation of "shaped" blocks such as are required to form the bursting charges for shell and for torpedos, and it has hitherto been the practice to build up such a charge from a number of discs and reduce them to the required shape and size in a lathe. By the new process such charges can be formed in a single block without any subsequent turning or other shaping being necessary.

Some of the chief advantages of the new process are :

1. There is no space wasted, as is the case with built-up charges, through slightly imperfect contact between the individual blocks, and thus, either a heavier charge (about 15% more guncotton) can be got into the same space, or less space will be occupied by a charge of given weight.

2. The metallic cases for solid charges may be much lighter than for built-up ones, since with the former their function is merely to prevent the absorption of moisture by dry guncotton. They can thus be made as light as possible, as the solid charge inside will prevent deformation during transport.

With built-up charges the case must be strong enough to prevent damage either to itself or to the charge it contains. For many uses a metal case, however light, may be discarded, and one of a thin waterproof material substituted.

This saving of weight will be of high importance under many circumstances.

3. The uniform density of charges made by this new process is very favorable to the complete and effective detonation of the entire mass, and to the presence of a uniform amount of moisture in every dart of the charge.

4. Any required density from 1.4 downwards may be obtained with exactitude and ease. Also, any required amount of moisture can be left in the charge, from the theoretical maximum corresponding to the density, which moisture is uniformly distributed through the charge.

These points are of the highest importance in cases where, like torpedo charges, it is essential to have the center of gravity of the charge in a predetermined position both vertically and longitudinally, and the charge so fixed in its containing case that the center of gravity cannot shift. The difficulty of ensuring this with a large torpedo charge built up from a great number of discs and segments is well known.

Where a number of similar charges with conoidal or other shaped ends have to be made, such as bursting charges for shell, they can, by this new process, be produced exactly to size without any turning, etc., being necessary, and reworking the "turnings" is also avoided.

Fig. 1 shows a shell charge for an 8-inch deck-piercing shell made by the old process, containing 25 pounds of wet guncotton; and Fig. 2, a charge occupying the same space for the same shell, weighing 28¾ pounds, made in one solid black by the new method, this illustrating the great saving of space by the new process.

The Government of the United States of America have adopted guncotton as the bursting charge for shell, after lengthy and exhaustive experiments with other well-known explosives.

The following are some extracts on the subject from the "Report of the Chief of Ordnance, 1898:"

"THE BOARD ON POWDERS AND HIGH EXPLOSIVES,
NEW YORK ARSENAL, 1ST OCTOBER, 1899.

* * * "As regards the bursting charges for shell, that for cast-iron shell, which is a black, fine grain powder, was readily provided, and the ordinary base percussion fuse for exploding it. In the case of the steel shell the case was otherwise. It had been found that black powder exploded in the steel A. P. and D. P. shell, which have very strong walls, did not prove sufficient to break up the shell sufficiently, and in some cases blew out the base plug, leaving the shell uninjured. A more powerful explosive, therefore, seemed to be a necessity for these steel shell, and for some time experiments had been in progress for the determination of a suitable high explosive for this purpose. Tests were made with wet guncotton, emmensite, and later with jovite, etc., but these last two have not resulted in such satisfactory results as to lead to their adoption.

"At the outbreak of the war the wet guncotton seemed to give the most satisfactory and reliable results, all things considered, and an order was placed with the New Explosives Company, of Stowmarket, England, for about 82 tons of wet guncotton, to be furnished in zinc cases that would fit the cavity of the projectiles for which they were intended. * * *

"*Recommendation.*—The Board recommends that wet compressed guncotton be adopted for high explosive shell charges for all projectiles of and above siege caliber."

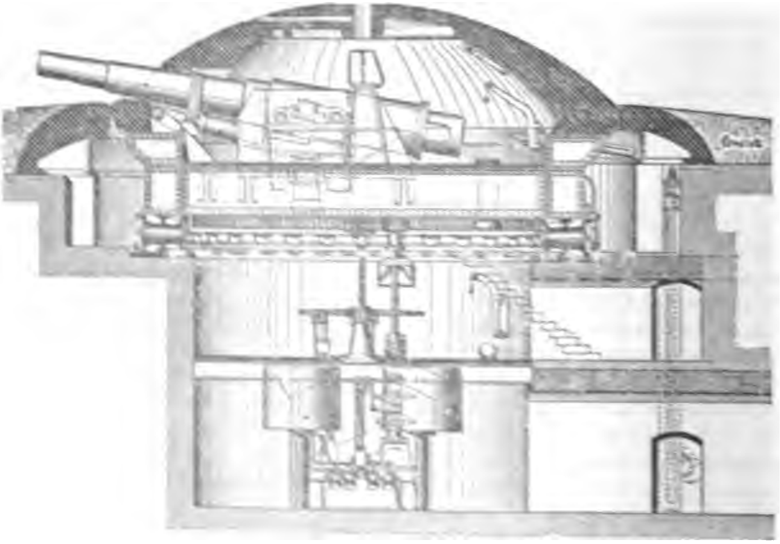
The report bears the signatures of Frank H. Phipps, Lieutenant Colonel, Ordnance Department, U. S. A., *President*; Sidney E. Stuart, Captain, Ordnance Department, U. S. A., and George Montgomery, Lieutenant, Ordnance Department, U. S. A. It is addressed to the Chief of Ordnance, U. S. Army, Washington.

We understand that the New Explosives Company, Limited, will contract for the supply of compressed guncotton made by this new process, or will sell the invention outright to any government or guncotton manufacturer, undertaking at the same time the erection of the necessary moulding and pressing machinery.

—*Arms and Explosives*, August, 1899.

The Gruson Chilled Cast-Iron Rotating Turret for Coast Fortifications.

The possible adoption of the Gruson revolving turret for mounting the great 16-inch coast defense gun now approaching completion at the Watervliet Arsenal makes a description of this device of special interest at the present time. As some of our readers may recall, this gun is to be located at Romer Shoals, at the entrance to New York Harbor, which is an exposed position for which the Gruson turret is considered to be especially adapted. Should this mounting be adopted here, it will be its first installation in the United States, although it has been frequently employed in European countries. The manufacture of the turret and the method of making the chilled cast-iron armor used in its construction are controlled by the Krupp Iron Works, of Germany,



[illegible] Iron Works, a [illegible] State of New York.

This company proposes to establish works for the manufacture of the turret and armor, and is now seeking a suitable location somewhere on tidewater, where the enormous armor plate castings of 100 tons weight and more can be handled directly on shipboard.

The Gruson turret is of the same general style for all sizes of coast defense rifles, but it, of course, varies in size, weight and power, to suit the dimensions of the gun which it protects. The accompanying cut shows this standard construction. Briefly described, the turret consists of a dome-shaped superstructure of armor plates mounted on a substructure of steel plate construction somewhat like the drum and turntable of a modern swing bridge. Large steel beams cross the drum to support the carriage on which the gun is mounted. The bottom edge of the drum rests on a ring of cone rollers, with collars like a spool, which runs on a track secured to the masonry. To protect the substructure the dome is surrounded by a ring of glacis armor imbedded in concrete masonry. This glacis armor ring is stationary, but the dome, of course, revolves on the roller ring. The power for revolution may be obtained from any kind of motor desired, steam being usually employed for the larger sizes of turrets. This motor is placed in the lower gallery and operates a vertical shaft having at its end a pinion, which gears with a rack on the inside of the circular drum. A capstan is provided for operating the turret by hand in cases of emergency, and there is also an arrangement for braking the turret to control its movements and to lock it in position. A hoist and hydraulic ram are provided for loading the gun.

The dome is perforated by two port holes, from which protrude the guns, and which so closely surround them that no projectile from the outside can penetrate into the interior of the turret. In order to make this possible the guns are mounted on special carriages, technically known as Gruson Minimum Port Carriages, which provide for the elevation and depression of the gun from a pivot near the center of the embrasure instead of having these movements take place on the trunnions of the gun. Such an arrangement makes it necessary to lift a considerable weight with every change in the elevation of the gun, and this is provided for by means of hydraulic accumulators which are kept in action by a special set of high pressure pumps. The traversing of the guns is effected by rotating the turret, the amount of such rotation necessary to a proper sighting being regulated by the commanding officer, who has his station in the center of the cupola, and makes his observations through an orifice in the dome or roof, which also contains a sighting apparatus.

The defensive feature of the turret is, of course, the armor plate dome. The plates which make up this dome are of a special quality of cast-iron, hardened by a surface chilling to a considerable depth. These plates or segments are doubled curved sections, and are held together with steel keys. Two half-circular plates are employed for the roof, but the number of circumferential plates differs according to the dimensions of the dome. The thickness of the plates differs, but reaches a maximum of 60 inches, and the weight often reaches 100 tons for a single plate. The total weight of the complete turret is sometimes 2,000 tons. As will be seen, the exterior surface of the dome is so designed as to deflect the projectiles, and break them up by receiving the blow on the side instead of the point of the projectile. The capacity of this chilled cast-iron armor to resist the attack of projectiles when it is employed in the position described has been shown by numerous tests made in Europe.

—*Engineering News*, July 13, 1899.

RANGE AND POSITION FINDING.

Automatic Sighting.

BY CAPTAIN H. S. JEUDWINE, R.A.

In a paper by Colonel Watkin, published in the *Proceedings* for June, 1898, some possible disadvantages attending the use of automatic sighting were brought forward. I venture to think, however, that the arguments which I am about to submit in favor of the system are so strong as to counterbalance any objections which have hitherto been raised.

The practical advantages which, it may be claimed, are conferred by automatic sights of the service pattern are:

I. Greatly increased rapidity of fire.
II. Increased accuracy of fire.
III. Diminished liability to disorganization of a command from hostile fire.
IV. The power of decentralization and its attendant benefits.

I. GREATLY INCREASED RAPIDITY OF FIRE.

This hardly requires proof. It is very evidently the case with the lighter Q. F. guns used against torpedo-boat attack, where all pauses in fire to give out ranges, or to set sights, are avoided. It is sufficient that with the 12-pr. Q. F. with automatic sights, a rate of fire of twelve rounds a minute is attained, at a target going from eighteen to twenty miles an hour, and with most accurate results. I am told that in the Royal Navy eight aimed rounds a minute is the best that is expected from a 12-pr. Q. F. (of course with ordinary sights) at a moving target. It is improbable that the Garrison gunner could do better, with such training as he is likely to get. We may take it therefore that automatic sights will increase the rate of fire of these guns (the mainstay of torpedo-boat defence) by fifty per cent., without lessening their accuracy. This is an immense advantage in the case of targets which are likely to be under fire for an extremely short space time. It may be mentioned that this advantage is practically independent of questions of range or site. Ranges will be short—probably not over 800 yards—and a height of twenty feet is sufficient.

In the case of the heavier B. L. guns the gain in rapidity of fire seems equally obvious. We are most of us pretty well acquainted with the ordinary delays which attend the gun group commander's "prediction." Added to this are delays in transmitting ranges, calling them out and putting them on the gun. With automatic sights these delays are impossible; the act of finding the range simultaneously lays the gun. Take the case of a 9·2-inch B. L. gun fitted with automatic sights, on a mounting such as R. C. D. are now turning out—the gun recoiling in a cradle and returning to the firing position; capable of being easily and quickly laid for elevation or direction by one man, the layer, who can also fire the gun with his eye to the sights; quick, easy and powerful loading gear. Surely it is not too much to hope for two rounds a minute from such gear, with automatic sights; or even three, if arrangements could be made to load cartridge and shell simultaneously.

There is no necessity to consider automatic sighting in connection with R. M. L. guns, to which it is understood there is no intention of applying it. It is to be hoped that all these obsolete and useless weapons may soon cease to cumber the ground. Their removal will promote not only efficiency, but economy also.

II. INCREASED ACCURACY OF FIRE.

One of the objections urged to automatic-sighting is its possible inaccuracy as compared with the ordinary systems of range-finding and laying.

To deal first with its use in connection with the lighter Q. F. guns for defence against torpedo-boat attack. It has been clearly demonstrated by practice that for heights of twenty-five feet and upwards its accuracy up to 1,200 yards leave nothing to be desired. No more is required of these guns.

Taking now the case of guns other than the above. Colonel Watkin has pointed out two objections, but they appear to have been met by improvements in manufacture, and should not now present real drawbacks to accuracy.

The first is the personal error of the layer, with a sight not provided with a telescope, which Colonel Watkin estimates at two minutes. This disadvantage is now obviated by the addition of an excellent telescope to each set of sights, for use if required, and they are, therefore, in this particular, on the same level as any range-finder as regards accuracy, since a given error with a range-finder in observation, or with automatic sights in laying, would cause in each case the same deviation in the quadrant elevation of the gun.

The second objection urged is the difficulty of ensuring a level platform, owing to racer, etc., going out of level.

Since automatic sights are not to be applied to R. M. L. carriages there is no need to reckon with these wobbly antiquities. In the case of B. L. mountings, which, owing to their being constructed on sounder mechanical principles, are less likely to go out of level, a means of levelling will be provided.* On the second point therefore we find the automatic sight again on an equality with the range-finder.

There are in addition some reasons why automatic sights should give greater accuracy than any range-finder.

They are as follows:

1. As there is a sight to each gun, each sight can be set, by means of the "error of the day" screw and adjusting foresight, to accommodate itself to any idiosyncracies of its own gun, or any peculiarties of its own layer. This can be done, with the help of trial shots, at any time before action.

2. There is only one personal error to affect the shooting—that of the layer—in place of two where a range-finder is used, those of the observer and gun captain (or layer) which may be cumulative.

3. That part of the gear of the service automatic sight which is essential to its accuracy as a range-finder is so extremely simple and strong, and works with such directness and absence of intervening parts, that there is apparently nothing which wear and tear can act on to produce error.

4. Automatic sights eliminate tidal errors. A range-finder can, of course, be corrected for height of tide, but there is still the quadrant elevation scale of the gun, which is graduated for mean tide, and must remain so. An error is, therefore, inevitable at all states of tide, excepting mean, descreasing with a higher site, increasing with a lower one, and only to be eliminated altogether

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* See "Changes in war matériel," § 9380, February, 1899.

by the clumsy method of making corrections in the range given by the range-finder. With automatic sights, on the other hand, tidal corrections are made, both as affecting the range-finding properties of the sight, and as affecting the quadrant elevation given to the gun, by the simple action of setting the tide lever.

5. Lastly, there must be added to the above the immunity, which is enjoyed when using automatic sights, from the mistakes of drum readers, dial numbers, gun group commanders, gun captains, or of the dials themselves. An inspection of any *accurately kept* practice report brings home to one pretty clearly what it means to get rid of all these possible sources of error.

III. DIMINISHED LIABILITY TO DISORGANIZATION OF A COMMAND FROM HOSTILE FIRE.

A range-finder (at all events inspection of our coast fortresses would make it seem so) must necessarily be so placed that no intelligent enemy could fail to detect it at once. The compliments his Q. F. and machine guns might be expected to pay it would probably soon disorganize it and its operators, with the result of disorganizing also a group and perhaps a whole battery command. Automatic sights on the other hand can be so shielded as to make them and their layers comparatively safe from machine and light Q. F. guns; and if one is damaged it is only one of the sights of one gun disorganized, and not a group or battery command.

A consideration of the volume of fire which can be poured from the decks of even a single battle-ship or cruiser should make us unwilling to incur unnecessary exposure of men or *matériel*, and careful to ensure that disorganization shall not be easy, even in the event of severe losses to both.

IV. THE POWER OF DECENTRALIZATION AND ITS ATTENDANT BENEFITS.

There can be no doubt that if we are to get the best value out of automatic sights our system of fire discipline with the heavier guns must be thoroughly remodelled, and this is anything but matter for regret.

Take the present conditions. Imagine a battery commander attempting to direct the fire of a command of three or four groups, possibly composed of guns of different natures and with quite distinct arcs of fire; served, perhaps, by a depression range-finder and two or more position-finders, the cells of the latter distant from him anything between 200 yards and two miles, with no direct communication to them, except perhaps through an unreliable telephone situated occasionally at some distance from the B. C.'s post; unable, maybe, to see his groups or to communicate with his gun group commanders except by orderly.

The above is no fancy picture, and the spectacle is a sad one. It can be seen nearly every time that a battery command is manned completely and practised from as it would have to be in action. Its lessons are not brought home to us as clearly or as often as they might be, because this practice from an entire battery command under any approach to service conditions is of extremely rare occurrence, except when the command offers rather more than the usual facilities for fire direction.

Automatic sights, assuming, which does not seem oversanguine, the supply of cordite to all guns so fitted [illegible], provide us with an exit from all these difficulties. Some such scheme of fire direction as the following would meet the case. The fire of each gun to be observed by its own layer, of each gun group by its own group commander, of each battery command by its battery commander. The layer to correct his fire as an ordinary rule, the group commander if he thinks necessary, the battery commander only in the event of erratic shooting which does not seem to be meeting with attention; he will probably be well advised not to interfere unless he deems it absolutely essential. The control of his groups is thus in no way taken out of the B. C.'s hands. He will still order them to commence or to cease fire; will select the part of the target to be attacked, and, where the F. C. does not do so, will select the target; will select the order of fire (though for the sake of effect it is natural to suppose that only the quickest rate of fire would be employed). The orders of fire might be considerably simplified, and those now in force for Q. F. guns seem applicable.

If necessary under this system more than one target might be engaged without difficulty by a battery command. This, although often very desirable on account of the different arcs of fire of groups, is at present only possible in the case of groups having separate position-finder. Great economy should also result. A large proportion of orderlies, dial numbers, telephone operators, range-finding observers, etc., would disappear and the number of expensive electrical communications would be largely reduced. Even fire commanders might occasionally be dispensed with, the senior battery commander, who would probably have leisure enough, at all events before action, performing his functions. To enable him to do this, however, his post must allow him a good view of the whole command and its approaches.

To sum up, automatic sighting seems to offer the one hope of a rational, economical, and efficient system of fire direction for coast artillery.

Rational, because it allows of division of responsibility and labor, and does not expect of one man performances which are beyond any one man's powers.

Economical, because its directness and simplicity allow of working with greatly decreased *personnel* and an absence of much of the costly *matériel* now installed; also because with the increased effect obtained from guns a smaller number will be required. (It is assumed that all R. M. L. guns are withdrawn; no amount of R. M. L. guns can by any possibility be considered equivalent to one 6-in. Q. F gun, with a moderate command, fitted with automatic sights, when the disparity between the cost of stores, weight of metal, and the number of men required to produce the same volume of fire is considered).

Efficient, because it allows more rapid and more accurate fire than any other system. It must be remembered, that what is required of Coast Artillery guns is, that they shall not only be hitters, but quick hitters. If it ever comes to real earnest with them, there will be a ship, perhaps several, trying to get to close quarters; if the ships get there, where the superiority in numbers of their light Q. F. and machine guns can tell, and the difference in accuracy between shore and ship is not so much felt, it means infinitely greater loss on shore, if not worse.

There was a time when cover and protection for shore guns appears to have been considered of first importance. This period produced those unwieldy monsters on disappearing and other mountings, which are good, under favorable conditions, for a round in every three or four minutes if they are in working order. The best protection from the enemy's fire is to hit him oftener and harder than he can hit us. We can do this even when greatly outmatched in number of guns (if we do not trust to obsolete and useless weapons) because we have generally command and always a fixed platform, and because while a very large proportion of his shells that hit our works do no damage at all, everyone of ours that hits him does probably a good deal. Guns that can be trusted to make an enemy's ship or ships sheer off, riddled and shattered—with luck, disabled or sinking—in the course of a few minutes, possess the best and the only true protection from fire, and such guns alone can perform the functions for which coast guns are intended.

For those who still doubt the wisdom of applying automatic sights at once to all our guns mounted at suitable heights, which are worth it, it may be noted that the service automatic sights are convertible into ordinary tangent sights, by a turn of a lever, in a second or two. They are then available for use with range-finders for laying in the ordinary way if desired. I do not believe, however, that this lever will have much work thrown on it.

There is, of course, one class of guns—high angle fire guns—to which automatic sights are useless. To these the position-finder is a necessity.

—*Proceedings Royal Artillery Institution*, March, 1899.

Auto-Sights.

Possible errors due to non-verticality of pivot.

BY MAJOR M. O. HOPKINS, R.A.

Recently I had occasion to calculate to what extent the range would be affected by want of level in the base-plate in the case of Q F. guns fitted with automatic sights. And one of the guns for which I worked this out was a 6" Q.F. at a height of 50 feet with a muzzle velocity of 1,552 f.s.

Calculating to the nearest yard, I found that in this case the errors in range which would arise from a want of level of 4' in the base-plate would be those shown in the following tabular statement:—

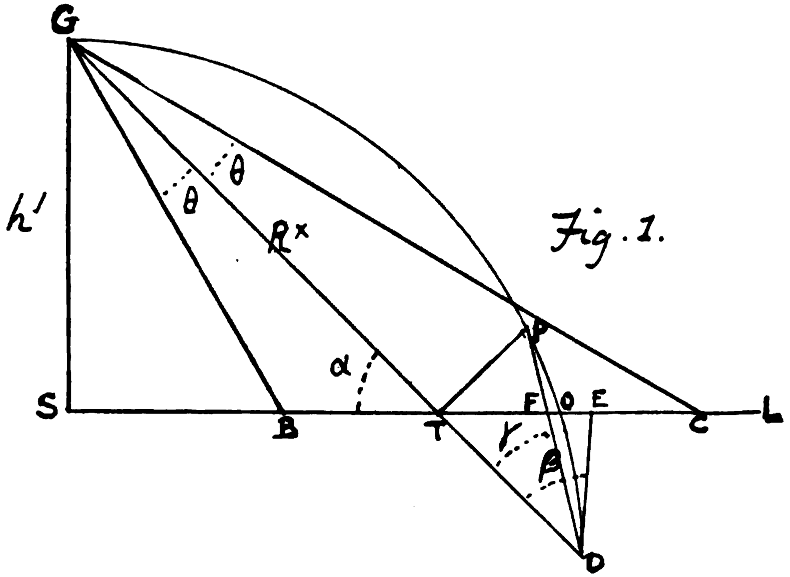
	Error.	
Range.	Mounting Depressed.	Mounting Elevated.
1000	+ 33 yards	— 31 yards.
2000	— 278 yards	— 200 yards.
3000	+ 752 yards	— 474 yards.
4000	+ 1512 yards	— 833 yards.

These figures differ very much from those given by Colonel H. S. S. Watkin, C.B., in the R.A.I. "Proceedings" of last June, and in a less degree, those for 4,000 yards, from the results arrived at by Colonel Sir G. S. Clarke, K.C.M.G. which were published in the "Proceedings" for March of this year.

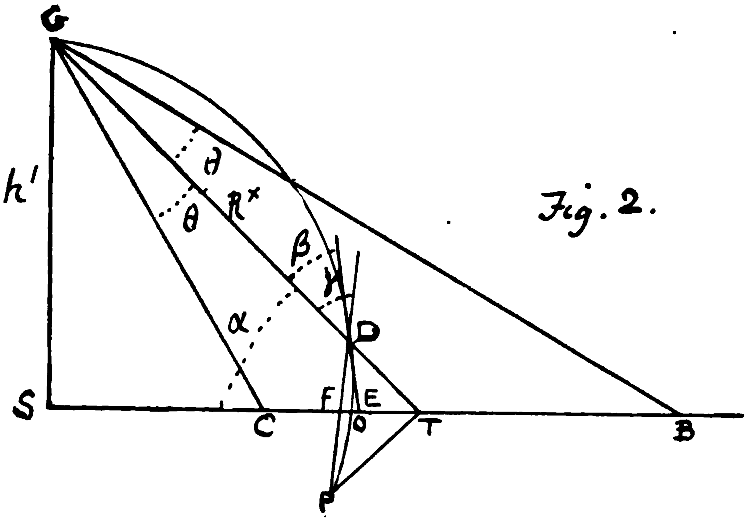
Whether my calculations are correct or not, I venture to publish them as a step towards the solution of a problem which is of the greatest importance to all garrison gunners. For, however truly base-plates and roller paths may be laid, they cannot always remain level; and there can be no doubt that a trifling want of level in them will cause great errors in range.

The required corrections for these errors cannot be put into the correction for the error of the day, since they will vary with the line of fire. In the majority of cases a Q.F. gun would have to follow the enemy's vessel through a large arc of fire. Such an arc might extend to 180°, and if the gun were a 6" Q.F. at the height of 50 feet and there happened to be an initial want of level of 4' when the first round was fired at a range of 4,000 yards, the last round being fired at the same range as the vessel passed out of arc, the corrections would vary with the range and training between + 1,512 and — 833, always supposing that my theory and calculations are correct.

They are as follows :



Let G, an automatically sighted gun at a height GS, or h' feet, above SL, the sea level, be correctly laid on T, a target which is at a range GT, or R yards. Then the trajectory will pass through T; that is the gun will have the tangent elevation of R. If the target now moves to another position, C; such that the line of sight in following it has to be raised (Fig. 1.) or depressed (Fig. 2.) through any angle θ, the trajectory will pass through C and the gun will have the tangent elevation due to the range GC. In other words if, when the gun has the tangent elevation due to R, (h being a constant) the line of



sight is altered through θ the gun will thereby have imparted to it the tangent elevation due to GC.

Let the gun be again correctly laid on T, and suppose the whole mounting to be tilted either to the front (Fig. 1.) or to the rear (Fig. 2.) along the line of fire through the angle θ. The line of sight will then become GB, but the tangent elevation will remain that due to R; and to bring the line of sight back to T, the gun-layer must move it through θ. In so doing he must inevitably impart to the gun the tangent elevation due to GC.

Make GD equal to GC; then, theoretically, when the line of sight is again on T, the trajectory will pass through D. Let the curve which (produced in Fig. 2.) cuts SL in O represent this trajectory. Then, when the range is R and the want of level is θ, TO is the resultant error measured along the sea level—as we invariably calculate errors in range.

Now, I cannot find the value of TO directly; but I can arrive at a very close approximation to it, in this way: from D with the angle of descent due to the range GC (or the angle β) lay off DE to cut SL in E, and through T erect a perpendicular to cut the trajectory in P. Join PD, cutting SL in F.

It is obvious that O must lie between E and F, and EF is very small. Calculating it out for the ranges and for the conditions named, I found that its maximum value was 14.7 yards; and that this was when the range was 4,000. If, then, we assume that TO is the mean of TE and TF, we must up to 4,000 yards be within considerably less than 8 yards of its actual value. It only remains to find TE and TF.

The angle GTS, or the range finding angle, is known since its sine $= \frac{h}{3R}$; the angle β is given in the range tables, and θ is assumed to be 4′. Let us call the range finding angle α, and assign to R any value.

$$\text{Then } GD = GC = \frac{R \sin \alpha}{\sin(\alpha - \theta)} \text{ (Fig. 1.)}$$

or

$$\frac{R \sin \alpha}{\sin(\alpha + \theta)} \text{ (Fig. 2.)} = \frac{h}{3 \sin(\alpha + \beta)}$$

and $TD = GD - R$ (Fig. 1.),

or

$$R - GD \text{ (Fig. 2.) and } TE = \frac{TD \sin \beta}{(\sin \alpha + \beta)}$$

Next, $TP = \frac{1}{2} gt(T - t)$ where T and t are the times of flight due to the ranges GC and R, T being always the greater. Thus, TP being known, the angle TDP (which we will designate γ) can be found from the equation:

$$\tan \gamma = \frac{TP}{TD} \qquad \text{and } TF = \frac{TD \sin \gamma}{\sin(\gamma + \alpha)}$$

Finally it is assumed that $TO = \frac{TE + TF}{2}$

It will be noticed that I have taken GT and GC instead of ST and SC as the ranges to T and C, and that I have calculated from its sine instead of from its tangent. But this method though unusual, can only tend to greater accuracy.

Note by Colonel Sir G. S. CLARKE, M.C.M.G., F.R.S., R.E.

Superintendent of the Royal Carriage Factory.

When a new adjunct of Coast Defence is placed in the hands of the Royal Artillery, I think it is undesirable that confidence should be shaken at the outset. If a dog obtains a bad name, we know what follows, and should a presuming and incompetent mongrel thrust itself upon the notice of the very "fierce dogs" of the Garrison Artillery a tragedy must inevitably be enacted. For this reason only I ventured to reply to the excellent paper of Colonel H. S. S. Watkin, C.B., and I now offer a few remarks on Major Hopkins's able analysis of one probable source of error which as I have already stated "any auto-sight inventor must evidently face."

Major Hopkins has quite correctly calculated the errors arising from an inclination of the axis of the mounting although, as Professor Greenhill points out, the process is somewhat unnecessarily laborious. I take exception, however, to the claim that this is "a step towards a solution of a problem which is of the greatest importance to Garrison Gunners." It seems to me to be an alarming but perfectly fair statement of a serious source of error unaccompanied by the vestage of a hint as to how that error may be met. In designing an auto-sight for service use, one of the earliest measures I took was to investigate fully the errors due to non-verticality of pivot. The formula which Professor Greenhill gives was the one adopted for the purpose, and it was evident from the first that (1). Verticality must be attained in the original laying of the cast-iron pedestals which I introduced in order to secure rigidity; or (2) means of subsequent adjustment must be provided; or (3) the sight itself must be capable of such manipulation as to give the necessary corrections. One of these three conditions must be fulfilled, or practical success in firing at a rapidly moving target could not be expected. I have explained that verticality is not essential to accurate practice at a fixed target, or when firing over a small arc of training. A limitation of this kind was, however, clearly inadmissable if the auto-sight was to be of real use to the Garrison Artillery, and the most careful consideration was, therefore, bestowed upon the problem of adjustment.

Practical experience of a varied kind has so far shown that a sufficient verticality can be secured to give admirable shooting. In my paper on "Auto-Sighting", I gave some results of rapid fire with a 4·7" quick-firing gun. The Director-General of Ordnance has very kindly permitted the publication of some further figures. (See Appendices A and B.)

Independant trials of my auto-sights have taken place at four widely dispersed stations with results such as these and in not a single case has any special levelling or adjusting device been employed. In practice, which after all is the real test, the terrible errors which Major Hopkins shows to be possible have never arisen. To all officers who might well feel staggered by the possibility of an error of 1,512 yards in 4,000 yards, I venture earnestly to commend a study of the actual results obtained.

This, however, is not all. I am well aware that a bad foundation has to be reckoned with, and that displacement of the axis of motion of a mounting may occur. This is provided for, though I am not at liberty to explain the means.

Conditions (2) and (3) *can* be fulfilled, and experience will show which of two absolutely different mechanical arrangement is best suited for the requirements of the garrison gunner. Meanwhile I ask him to regard the figures at his disposal as evidence of what the auto-sight has already done, and to trust his new adjunct. Still better results will be obtained when the use of the sight has become familiar. The verticality of the axis question is a bugbear which, like others of the species, shrivels when one goes up to it.

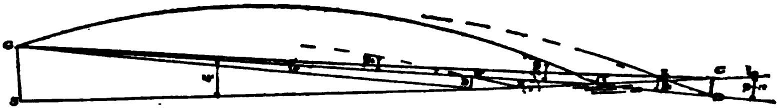
I believe it is not too much to say that auto-sighting will add 50% to the efficiency of the fire of coast artillery.

Note by **Professor A. G. Greenhill**, M.A., F.R.S.

Professor of Applied Mathematics at the Ordnance College.

The mathematical treatment of this subject is quite correct, but a little more laborious than is necessary. I think TO may be replaced by TE, in the author's figure 1, with sufficient accuracy for practical purposes, provided the suitable value of β is chosen.

Fig. 2.



If the pivot leans forward 4′, and the sight is directed on the target T, the automatic sight will give the elevation requisite for the range GC, so that the trajectory will be GED, where GD = GC.

Drawing DE, making the angle TDE equal to β_1 the range table angle of descent at the range GC or GD to cut the sea level SL in E, then E may be taken with sufficient accuracy as the point where the shot strikes the water, and the error in range is

$$TE = \triangle_1 R \; (+) \text{ suppose.}$$

Then

$$\triangle_1 R = TE = TD \frac{\sin \beta_1}{\sin(\beta_1 + M)} \quad [\text{and } TD = TC]$$

$$= TC \frac{\sin \beta_1}{\sin(\beta_1 + M)}$$

$$= \frac{Tt}{\sin(M - 4)} \frac{\sin \beta_1}{\sin(\beta_1 + M)}$$

$$= GT \frac{\sin 4' \sin \beta_1}{\sin(M-4) \sin(\beta_1 + M)}$$

and GT = R, while the sines may be replaced by the angles, all expressed in minutes, so that

$$\frac{\triangle_1 R}{R} = \frac{4 \times \beta_1'}{(M'-4')(\beta_1' + M')}$$

and the percentage error is

$$100 \frac{\triangle_1 R}{R} = \frac{400\, \beta_1}{(M-4)\,(\beta_1 + M)} \; \%.$$

$$= \frac{400\, \beta}{(M-4)\,(\beta + M)}$$

taking β and β_1 as practically undistinguishable.

So also, if $\triangle_2 R$ denotes the error (—) in range R, when the pivot leans backward 4′,

$$\frac{\triangle_2 R}{R} = \frac{4 \times \beta_2'}{(M + 4)\,(\beta_2 + M)} = \frac{4\,\beta}{(M + 4)\,(\beta + M)}$$

This from the Range Table of the 6-in. Q.F. gun, Muzzle Velocity, 1,882 feet per second.

Range.	1000 yards.	2000 yards.	3000 yards	4000 yards.
β	57′	138′	258′	404′
$M = 1146 \frac{h}{R}$	57′	29′	19′	14′
$\beta + M$	114′	167′	277′	418′
$M - 4$	53′	25′	15′	10′
$M + 4$	61′	33′	23′	18′
$109 \frac{\Delta_1 h}{R}$	3.7%	13%	25%	38%
$= \frac{400\,\beta}{(M-4)\,(\beta+M)}$ $\Delta_1 h$	37 yds (33)	260 yds (278)	750 yds (752)	1520 yds (1512)
$100 \frac{\Delta_2 h}{h}$	3.3%	10%	16%	21%
$= \frac{400\,\beta}{(M+4)\,(\beta+M)}$ $\Delta_2 h$	33 yds (31)	200 yds (200)	480 yds (474)	840 yds (833)

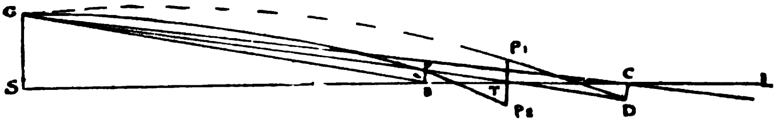
The agreement between these results and those given by the author is sufficiently close for practical purposes.

Astronomers are careful to give the corrections required for errors of adjustment in their instruments, so gunners need not be afraid to make a similar careful survey of the corrections unavoidable in manufacture, for such delicate adjustments as those required with automatic sights.

I think the author should examine explicitly the error on a *vertical* target due to want of level of the base-plate, as this error is of more practical importance than the error of range.

This vertical error is practically the author's TP in his Fig. 1; and in Fig. 4,

Fig. 4.



$TP_1 = 16tt_1$ feet, where t_1 is the extra time of flight for the range GC; while $TP_2 = 16tt_2$ feet, where t_2 is the defect in time of flight for the range GB, t denoting the time of flight for the real range GT.

$$\frac{GC}{GT} = \frac{\sin M}{\sin (M - 4)} = \frac{M}{M - 4}; \quad \frac{GB}{GT} = \frac{M}{M + 4}; \quad M = \frac{1145\,h.}{R}$$

This vertical error becomes serious at ranges of 3000 yds. and over; but I do not think it was ever intended that the automatic sight should be employed at these long ranges with such a small command as 50 feet. The correction for tide level would now become of equal importance; and Major Dunlop points out that the two corrections for tide level and for level of base plate, can be carried out in the same manner.

Range $G\ T$.	1000 yards.	2000 yards.	3000 yards.	4000 yards.
M	57	29	19	14
$M-4$	53	25	15	10
GC	$\frac{57}{53} \times 1000$ = 1075 yds.	$\frac{29}{25} \times 2000$ = 2320	$\frac{19}{15} \times 3000$ = 3800	$\frac{14}{10} \times 4000$ = 5603
(From Range Table) $t+t_1$	1.835	4.43	8.25	13.4
t	1.73	3.73	6.10	8.0
t_1	0.1	0.7	2.15	5.4
$\log t$	0.2380	0.5717	0.7853	0.9031
$\log t_1$	$\bar{1}.0000$	$\bar{1}.8451$	4.3324	0.7324
$\log \frac{1}{2} g = \log 16$	1.2041	1.2041	1.2041	1.2041
$\log T P_1$	0.4421	1.6209	2 3218	2.8396
$T P_1$	2.768 ft.	41.78	209.8	691.1 ft.
M	57	29	19	14
$M+4$	61	33	23	18
GB	$\frac{57}{61} \times 1000$ = 935 yds.	$\frac{29}{33} \times 2000$ = 1760 yds.	$\frac{19}{23} \times 3000$ 2500 yds.	$\frac{14}{18} \times 4000$ 3100 yds.
(From Range Table) $t-t_2$	1.63	3.17	4.86	6.36
t	1.73	3.73	6.10	8.0
t_2	0.1	0.56	1.24	0.64
$\log t$	0.2380	0.5717	0.7853	1.9031
$\log t_2$	$\bar{1}.0000$	$\bar{1}.7482$	0.0934	0.2148
$\log 16$	1.2041	1.2041	1.2041	1.2041
$\log TP_2$	0.4421	1.5240	2.0828	2.3220
TP_2	2.765	33.42	121.1	209.9 ft.

Note by Major H. C. DUNLOP, R.A.

Professor of Artillery at the Ordnance College.

If E denotes the error due to laying or that in the level of the racers, Professor Greenhill's first formula becomes

$$(1). \qquad \frac{\Delta R}{R} = \frac{\mp E B}{(M \pm E)\ (B + M)}$$

At long ranges where B is large as compared with M it becomes

$$(2). \qquad \frac{\Delta R}{R} = \frac{\mp E}{M \pm E}$$

which is the formula for a depression range finder or position finder out of level or badly laid.

Again if p is the percentage too low or too high of the setting of the tide lever, and if there is no error in the racers or laying, the formula becomes

$$(3). \qquad \Delta R = \frac{\pm p M B}{\{M (100 \pm p)\}\ (B + M)} = \frac{\mp p B}{(100 \pm p)\ (B + M)}$$

At long ranges where B is large as compared with M this becomes

$$(4).\qquad \frac{\triangle R}{R} = \frac{\mp P}{100 \pm p}$$

which is the formula for a Position Finder or Depression Range Finder with a similar error in the setting of the height.

Now formulæ (2) and (4) are always greater than formulæ (1) and (3). In other words such errors as we have considered affect a position finder or depression range finder more than an auto-sight. It is well known that they affect ordinary laying less. But we must remember that an auto-sight combines range finding and laying, so that, when considering its errors, we must compare them with all the errors resulting from the combined use of a depression range finder *and* the ordinary laying appliance. There are then so many errors and so many corrections and sometimes so many cooks that it is doubtful if there can be any satisfactory test except hits at practice. It is quite certain that, though in helping to trace the causes of misses they have their uses, formulæ and figures can prove anything except the probability of the assumptions or the reliability of the statistics on which they are based. We require an enormous mass of such circumstantial evidence before we can hope even to approach the truth, but direct hits are direct evidence and credible. (*See Appendics A and B*, *Pp.* 74 *and* 75.)

—*Proceedings Royal Artillery Institution*, September, 1899.

Appendix A.

SOME TYPICAL RESULTS OF ACTUAL PRACTICE WITH AUTOMATIC SIGHTS.

With 6″ Quich-Firing Gun.

Time.	Range.			Tide above or below mean tide level	Correction on drum.	Deflection.	Results judged by Range Officer. + or —	Remarks.
	D.R.F.	P.F.	On drum					
				Height of gun above mean sea level = 301 feet.				
	yards	yards	yards	± feet	yards	mins.	yards	
				2,000 yards. Automatic sight with telescope. Deliberate.				
p.m.								
4.15.50	1,925	...	1,900	—0′ 6″	Nil.	2 R	Hit.	Wind force, about 2.
4.16.	1,925	...	1,900	—0′ 6″	Nil.	2 R	+10	Sea Smooth.
4.16.10	1,925	...	1,900	—0′ 6″	Nil.	2 R	+10	Target drifting slowly.
4.16.30	1,875	...	1,800	—0′ 6″	Nil.	2 R	—10	
4.16.55	1,775	...	1,750	—0′ 6″	Nil.	2 R	Hit.	Electric firing gear used.
				2,000 yards. Automatic sight with telescope. Rapid.				
4.18	2,030	...	2,000	—0′ 6″	Nil.	2 R	Hit.	Wind force, about 2.
4.18.8	1,975	...	1,950	—0′ 6″	Nil.	2 R	—20	Sea smooth. Target drift-
4.18.30	1,925	...	1,900	—0′ 6″	Nil.	2 R	+20	ing. Time, 52 seconds.
4.18.35	1,975	...	1,950	—0′ 6″	Nil.	2 R	+10	Whole of target knocked
4.18.30	1,975	...	1,950	—0′ 6″	Nil.	2 R	Hit.	away. Fire continued on platform which formed a fairly good objective.
				3,000 yards. Automatic sight without telescope. Deliberate.				
3.1.39	2,965	2,990	2,825	—1′ 0″	Nil.	Nil.	—60	Wind (gusty) 4. Sea chop-
3.1.55	2,980	3,010	2,900	—1′ 0″	Nil.	Nil.	—20	py. Hazy at times.
3.2.10	2,985	3,010	2,975	—1′ 0″	Nil.	Nil.	Hit.	Target, broken up.
3.2.22½	2,900	3,080	2,975	—1′ 0″	Nil.	Nil.	- 30	
3.2.37	3,000	3,020	3,000	—1′ 0″	Nil.	Nil.	- 40	
				3,000 yards. Automatic sight without telescope. Rapid.				
3.4.5	3,060	3,080	3,400	—1′ 0″	Nil.	Nil.	Range	Wind 2. Sea choppy.
3.4.18	3,070	3,090	3,400	—1′ 0″	Nil.	Nil.	-300	Hazy at times.
3.4.30	3,075	3,100	3,375	—1′ 0″	Nil.	Nil.	-250	Knocked target over. Lay-
3.5.45	3,120	3,150	3,275	—1′ 0″	Nil.	Nil.	- 20	ing not altogether reliable
3.6	3,125	3,150	3,275	—1′ 0″	Nil.	Nil.	+ 20	as target was now a bad objective, only small portion left. Time, 40 sec's.
				4,000 yards. Automatic sight with telescope. Rapid.				
4.34.10	3,815	3,860	3,800	—2′ 0″	Nil.	8 L	-20	Wind 2. Sea choppy.
4.34.22	3,820	3,860	3,800	—2′ 0″	Nil.	8 L	- 30	Hazy at times.
4.34.32½	3,820	3,860	3,825	—2′ 0″	Nil.	8 L	-50	Target, drifting.
4.34.43½	3,820	3,870	3,825	—2′ 0″	Nil.	8 L	- 40	Time, 44 seconds.
4.34.55	3,820	3,890	3,825	—2′ 0″	Nil.	8 L	-15	
11.18.38	4,125	4,140	4,200	+1′ 6″	Nil.	15 L	+30	Wind 6. Raining at in-
11.18.48	4,125	4,140	4,200	+1′ 6″	Nil.	15 L	- 80	tervals.
11.18.58	4,130	4,140	4,200	+1′ 6″	Nil.	10 L	- 50	Target towed 6 miles an
11.19.8	4,130	4,140	4,150	+1′ 6″	Nil.	10 L	- 30	hour. Target somewhat
11.19.19	4,130	4,140	4,100	+1′ 6″	Nil.	10 L	- 20	indistinct at times, ow-
11.19.28	4,130	4,140	4,125	+1′ 6″	Nil.	10 L	+40	ing to spray being blown
11.19.38½	4,125	4,140	4,200	+1′ 6″	Nil.	10 L	- 30	back over it.
11.19.58	4,120	4,140	4,150	+1′ 6″	Nil.	10 L	Hit.	Breech jammed, causing
11.20.11	4,120	4,150	4,200	+1′ 6″	Nil	10 L	- 40	30 seconds delay, and
11.20.34	4,130	4,150	4,200	+1′ 6″	Nil.	10 L	- 50	force used in opening it
11.20.47	4,140	4,160	4,200	+1′ 6″	Nil.	10 L	- 70	threw gun right off target
11.20.57	4,150	4,160	4,225	+1′ 6″	Nil.	10 L	- 100	Breech jamming possibly
11.21.10	4,150	4,170	4,200	+1′ 6″	Nil.	10 L	- 70	caused by metal washer
11.21.20	4,150	4,170	4,170	+1′ 6″	Nil.	10 L	Hit.	from electric primer
11.21.32	4,150	4,170	4,200	+1′ 6″	Nil.	10 L	Hit.	dropping out of empty
11.21.51	4,150	4,180	4,200	+1′ 6″	Nil.	10 L	- 50	cartrige case.
11.22.1	4,150	4,190	4,200	+1′ 6″	Nil.	10 L	70	Several of these washers
11.22.12	4,150	4,190	4,200	+1′ 6″	Nil.	10 L	Hit.	were found lying in
11.22.23	4,170	4,190	4,200	+1′ 6″	Nil.	10 L	Broke up	breech screw during prac
11.22.35	4,170	4,190	4,275	+1′ 6″	Nil.	10 L	+120	tice Gun became so hot
11.22.47	4,175	4,200	4,300	+1′ 6″	Nil.	10 L	+130	that the rain caused the
11.22.55	4,175	4,190	4,250	+1′ 6″	Nil.	10 L	+110	gun to steam and may
11.23.8	4,180	4,190	4,200	+1′ 6″	Nil.	10 L	Hit.	have interfered with lay-
11.23.19	4,180	4,200	4,200	+1′ 6″	Nil.	10 L	50	ing Mud from parapet
11.23.30	4,180	4,200	4,150	+1′ 6″	Nil	10 L	25	was blown back incon-
11.23.40	4,180	4,190	4,150	+1′ 6″	Nil.	10 L	+15	veniencing the Battery
11.23.50	4,180	4,180	4,150	+1′ 6″	Nil	10 L	Hit	Commander and detach-
11.24.1	4,180	4,190	4,175	+1′ 6″	Nil.	10 L	Hit	ment. Round 150 broke
11.24.12	4,180	4,190	4,175	+1′ 6″	Nil.	10 L	Hit	up on leaving the bore.
11.24.23	4,180	4,190	4,200	+1′ 6″	Nil.	10 L	- 70	Time, 5 minutes, 45 secs.

Appendix B.

SOME TYPICAL RESULTS OF ACTUAL PRACTICE WITH AUTOMATIC SIGHTS.

With 4.7″ Quick-Firing Gun.

Range.		Tide above or below mean tide level	Correction on drum.	Deflection.	Result.		Remarks.
D.R.F.	On drum				+ −	R. or L.	
yards.	yards	yards.	yards.	yards.	yards.	yards.	

At moving target, range 2,800—2,500 yards, rate about four miles an hour.

Time, 6 minutes 30.6 seconds (delay of about 2½ mins. to pick up the target which the layer had lost and which could not be seen with the naked eye.

Time not taken owing to delays in finding the target.)

Height of gun above mean sea level 161½ feet.

...	...	...	+50	5 R		...	
...	...	..	+35	5 R		...	
...	...	...	...	...	Range.	...	
...	...	...	...	...	+20	...	
...	...	...	...	...	+15	...	
...	...	...	...	...	+ 5	...	
...	...	...	...	...	+10	...	Hit.
...	...	...	...	...	− 3	...	
...	...	...	...	...	+ 5	...	
...	...	...	...	...	+15	...	
...	...	...	...	...	+10	...	
...	...	...	...	...	−15	...	
...	...	...	...	...	−15	...	
...	...	...	...	...	Range.	...	Hit.
...	...	...	...	...	−50	...	
. .	...	...	...	...	−20	..	
...	...	...	...	...	− 7	...	
...	...	...	...	...	−50	...	Front flag knocked away 5th round, and barrel knocked away at 12th round. Rear of target laid on for remainder of series.
..	...	...	...	...	+ 7	..	
...	...	...	...	...	+10	...	
...	...	...	...	...	+ 1	...	
...	...	...	...	...	+ 2	...	
...	...	...	...	...	− 5	...	
...	...	...	...	...	−40	...	

Height of Gun above mean sea level 138½ feet.

...	...	...	...	...	−20	...	
...	...	...	...	...	−10	...	
...	...	...	..	...	−90	...	
...	...	...	...	...	+60	...	
...	...	...	...	...	−10	...	
...	...	...	...	...	Range.	...	
...	...	...	...	...	+ 2	..	
...	...	...	...	...	− 5	...	
...	...	...	...	...	− 7	...	

ARTILLERY MATERIAL.

(Continued from page 62.)

An Ignition of Cordite.

Report to the Right Honourable the Secretary of State for the Home Department, on the circumstances attending an ignition of cordite, which occured in the blending and packing house of the factory of Messrs. Kynoch Limited, at Holehaven, Essex, on the 8th June, 1899, by COLONEL A. FORD, C.B., H.M. Chief Inspector of Explosives.

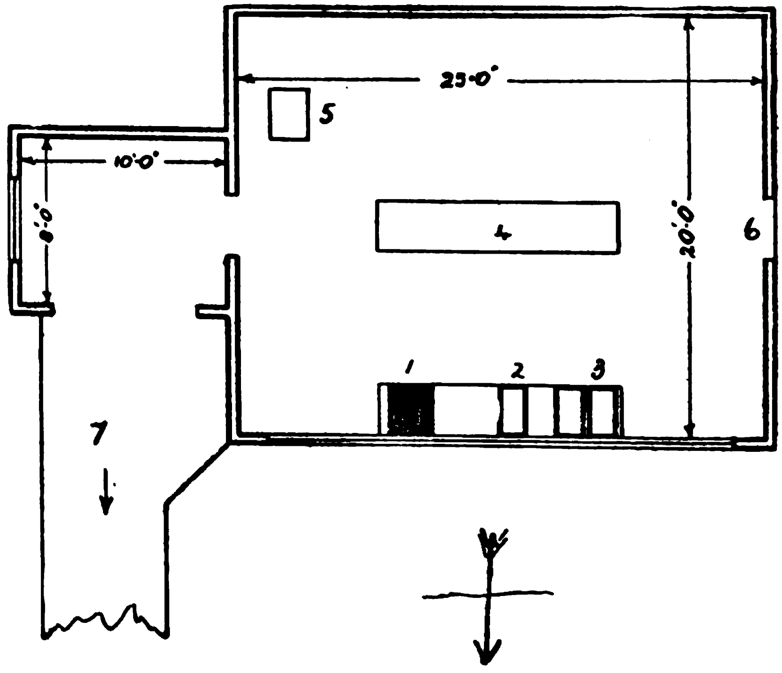
Home Office,
8th August, 1899.

Sir,

I have the honour to report that, in obedience to your Order of the 15th instant,[*] made under the 66th Section of the Explosives Act, 1875, I have held an Inquiry into the circumstances attending the Ignition of Cordite, which occured in the Blending and Packing House of the Factory of Messrs. Kynoch Limited, at Holehaven, Essex, on the 8th June, 1899. Of the three men working in the building at the time two, most fortunately, were uninjured, while the third sustained only slight burns on one of his ears.

In accordance with the provisions of the above-named Section of the Act, I beg to render the following Report.

Holehaven Factory has been erected on a site of about 200 acres, on marshes near the Thames, in the parish of Corringham. It dates from the 9th November 1897, when a License (No. 121) to manufacture certain nitro-glycerine compounds, including cordite,[†] and other explosives, on the site was granted to Messrs. Kynoch Limited, of James Street, Haymarket, who have other factories for explosives at Witton, near Birmingham, at Worsbrough Dale, near Barnsley, and at Arklow. The site is an excellent one for the manufacture, being far from all "protected works," excepting the river wall made to



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[*] Home Office papers, X 60 148 R 16.

[†] Cordite is defined as consisting of thoroughly purified guncotton (as hereinafter defined), mixed and incorporated with thoroughly purified nitro-glycerine and mineral jelly free from acid by means of acetone; the whole to be of such character and consistency as not to be liable to liquefaction or exudation

Guncotton consisting of thoroughly purified nitro-cotton (a) of which not more than 15 per cent. is soluble in ether alcohol and (b) which contains more than 12.3 per cent. of nitrogen, and with or without carbonate of calcium.

prevent inundation at high tides; and the buildings are placed at suitable distances apart, and are of approved construction, being on concrete piers three to four feet high, so that they may not be liable to become damp from the marshy ground, and are connected by wide platforms level with the floors.

The building in which the ignition took place was of galvanized iron, lined with wood, with a layer of felt between, the lining being kept nicely varnished. Its dimensions were 25 feet long by 20 feet wide, and it was 25 feet high to the eaves; it was provided with a porch 10 feet by 8 feet at the east side, with a door facing towards the north. The floor was of close-joined wood. The building had a window facing the north, and there was an extra door on the west side to be used as a means of escape for the workpeople in case of emergency.

The interior arrangement will be seen from the accompanying plan, which has been prepared for me by Mr. William Cullen, the Manager of the Factory. The building contained two tables, one near the window at the place marked 1, 2, 3; the other at 4, in the centre.

The operations carried on in the building were blending and packing cordite, the amount of explosive being limited to 2,000 lbs.; the number of workmen was not to exceed six.

Messrs. Kynoch Limited have been supplying cordite by contract to the War Office, and in March last they sent two 5-ton lots of the size 30/24[*] to Purfleet for proof. These lots were numbered K 286 and K 288. They passed the firing test successfully in April,[†] but it was noticed by the proof officers that some of the cords were "sweating" or showing signs of exudation, either of nitro-glycerine or acetone,[‡] and the whole consignment was therefore placed under observation in the Purfleet Magazines. The defect was not removed, but rather increased by the keeping, and in consequence both the lots were finally rejected on the 25th May,[§] and were returned to the Holehaven Factory on the 7th June.

On the next day, viz. the 8th June, the manager of the works gave directions that lot K 288 was to be examined; the cords found to be in good condition were to be re-blended with a small addition of new cords slightly larger in diameter, in order to reduce the initial velocity,[‖] which had been found somewhat high at the proof. Three men, Arthur Herbert Curtis, leading hand, William Bacon and Frederick Bacon, were employed at the work, which was carried on in the building. The method of work was as follows:—12 boxes (each containing 80 lbs.) were opened and placed in a row on the centre table (4 on the plan) with three boxes of new cordite, one of these boxes being at each end and the third in the middle of the other boxes. Each of the two men, William Bacon and Frederick Bacon, then walked round the table, taking five or six cords at a time from each box, and deposited his handful on the north table in front of the window for inspection by Curtis. Curtis spread out the cords on the table with his left hand, so that he might the better see them, and having selected any that appeared to him to be defective, he placed those in a box on the floor on his left side, and the remainder he packed into another box on the table.

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[*] That is to say, the cords were 0.3 inch in diameter and 24 inches in length.

[†] Lot K 288 really gave 4 f.s. too high initial velocity, but this was not considered sufficient ground for causing its rejection.

[‡] The greater part of these two lots was manufactured during the cold weather of February. Cordite made in very cold weather appears to be liable to sweat.

[§] War Office letter $\begin{array}{c}\text{M}\\ \hline 110{,}349\\ \hline 53.\end{array}$

[‖] The normal diameter was still .3 inch, but in manufacture by the million some cords are found to be very slightly thicker than others.

At 5.15 p.m. the cordite on the north table had accumulated—it was estimated at about 40 lbs.—and the two Bacons went to help Curtis in his examination. Curtis was standing on the right, William Bacon being in the middle, and Frederick Bacon on the left, in the positions 1, 2 and 3 respectively on the plan. At that time there were two full boxes and one empty box on the table, and there were three full boxes screwed down on the floor at the south side of the building (5 on the plan) ready for removal to the magazine. The whole of the cordite in the building had been contained in the fifteen boxes now on the table, excepting a portion of the defective cords from previous boxes, which had proved to be very few, there being not more than about five in each 80 lb. box, and two small reels of small-arm cordite.¶ The total amount in all probability did not exceed 1,300 lbs.

Curtis was spreading out, or "sliding down" as he termed it, the 40 lbs. in front of him, as usual, with his left hand, in order to level the cords on the table, when he saw a flash close to the window at the further end of one of them. He shouted to the two other men, "Go," and they all rushed out through the door in the porch on to the platform (7 on the plan), the only injury sustained being by Frederick Bacon, whose right ear was slightly burned. He was the last of the three to escape, and as he left the door, the flames were already bursting out through the window.

The cordite burnt fiercely without explosion, that in the closed up boxes being attended with a sound similar to the escape of steam from a boiler; the building was burned to the foundations, very little charred wood of the rafters and flooring being left. The fire was extinguished in about 35 minutes by hose pipes and buckets.

No damage was done to any other building of the factory, and the fire did not extend to the platform, which was, however, more or less charred by the heat to a distance of about 10 yards, but the grass on the marshes was burnt in the direction of the wind as far as 27 yards.

The detailed account given above of the circumstances which led to and which attended the ignition was obtained from the evidence of the three men who were working in the building. As above stated, they escaped uninjured, excepting only very slight burns on the right ear of one of them. Their wonderful escape enabled me to obtain evidence which in similar cases is usually meagre or perhaps entirely wanting.

From this evidence the condition of things immediately preceding the ignition was as follows:—

The three men had returned to the building after dinner at half-past one o'clock, and had been engaged continuously at the work all the afternoon, neither of them having left it during the time. A very small proportion of the cords had been found to be defective,† and had been placed in a box on the floor near the north table. There were two full boxes of cordite and about 40 lbs. of unexamined cords on the north table. On the centre table there were fifteen open boxes containing in all 700 to 800 lbs.

¶ Statement of the foreman, Adam Seip, who had been present in the building at times during the day, and whose last visit to it was about an hour before the ignition.

† Estimated at not exceeding 2 per cent. during the morning, but the proportion was somewhat larger in the afternoon.

Adam Seip, the foreman, had visited the building from time to time during the afternoon, his last visit being about an hour previous to the ignition.

About 1.45 p.m. the building was visited by John Bernard O'Sullivan, magazine keeper, and Bertram Gilbert, foreman of the dynamite packing house. The object of their visit was to obtain a screwdriver, which they took away with them.

Gilbert came again to the building shortly after 5 o'clock, about 6 or 7 minutes before the ignition, in company with Mr. Rowston, a chemist at the works; neither of them went inside the building, but Gilbert, standing outside the footboard,[*] placed two packages containing 10 lbs. of kynite[‡] on some empty cordite reels near the three packed boxes of cordite, in order that they might be taken away by O'Sullivan when he next visited the building.[§]

It is a curious coincidence, that I had myself also visited the building. in company with Mr. Cullen and Adam Seip, about half past two that afternoon in the course of an ordinary inspection. The three men were then engaged in blending the cordite in the manner described. I noted that the building was very clean and nice, and that the quantity of explosive was well below the limit assigned (viz. 2,000 lbs.).

Suddenly, about 5.15 p. m., a flash is seen by Curtis, *two feet from him*, at the end of one of the sticks as he is leveling them on the table, and there is barely time for the men to escape before the building is enveloped in flames.

An ignition under such a condition of things must be admitted to be of a most exceptional character. A cordite blending and packing house may be justly looked upon as one of the safest of "danger" buildings. It is perhaps the last of all the buildings employed for the manufacture in which such an accident would be looked for. How then could it have been brought about?

In all "chemical" explosives such as dynamite or cordite there is, first of all, a possibiliy of spontaneous ignition the result of decomposition, owing to the presence of some impurity. This, however, could only happen in a case where the explosive is confined, as for example when contained in a box in a magazine; in the open air, the "heating" could not take place.[‖] Moreover, a sample (No. 5920) of the lot K 488, examined by Dr. Dupré, F.R.S., whose report will be found in Appendix A, proved to be satisfactory and not liable to spontaneous ignition.[¶] The idea, therefore, that the ignition might thus have been caused may be confidently dismissed.

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[*] A sliding board placed to mark the boundary of the "clean" floor on which only the working shoes or magazine boots are allowed.

[‡] An explosive consisting of not more than 27 parts by weight of thoroughly purified nitro-glycerine (with or without the addition of not more than half a part of sulphuretted benzol), uniformly mixed with not less than 73 parts by weight of a pulverized preparation consisting of wood-meal, not less than 40 parts, nitrates of potassium, barium, and sodium (or either of them), not more than 36 parts, and carbonates of sodium and calcium (or either of them), not more than half a part, such preparation to be sufficiently absorbent when mixed in the above proportions to prevent exudation of nitro-glycerine.

[§] This is an irregularity, as the kynite ought not to have been deposited in the building at all; but it obviously had nothing to do with the ignition of the cordite, which took place on the north table. Two 5 lb. packages of kynite had been found to be defective in a 50 lb. box, and Mr. Rowston had directed Gilbert to re-pack them. When they had been re-packed O'Sullivan was engaged elsewhere, and Gilbert and Mr. Rowston left them at No. 6, where they knew O'Sullivan must call for the re-packed cordite, in order that they might find their way into his hands.

[‖] There were steam pipes in the building but it was not artificially heated at the time.

[¶] It will be seen that although the War Office test for cordite is 30 minutes the sample stood the heat test for 25 minutes, or ten minutes more than the time required in the examination of similar explosives for complete purification.

Next, there was no machinery in the building to bring about an ignition, and the only tool appears to have been a brass spanner which was lying on the north table. As the ignition took place *on* the table, it is unnecessary to discuss the question as to whether the fall of a brass spanner from a table on to the floor of a building would be liable to cause the ignition of cordite lying on the floor. The ignition, therefore, was clearly not due to machinery or tools in the building.

Again, the consideration that the ignition took place on the table enables me to remove from the list of possible causes all foreign substances which may have been on the floor or in any other part of the building. Thus, it is obvious that it could not have been caused by stones, grit, &c., brought in on shoes or clothes or blown into the building. A match dropped on to the floor or left lying about, or cotton waste could not have been the cause for the same reason. Foreign substances on the floor, or in any other part of the building, cannot, therefore, find a place in the list of the possible sources of the ignition.

Further, fire from an external source could not have caused it. There was no lightning at the time: there was no adjacent chimney to emit a spark; no engine passed near to the building: as the men had been working there for more than 3½ hours fire could not have been smouldering on their clothes; and lastly, there could not have been concentration of the sun's rays on the window which faced the north.

At first sight, a lucifer match, accidently brought into the building upon one of the men's clothes and dropped upon the table, appeared to me to carry great weight as a not improbable explanation of the matter. In spite of the men having no pockets in their clothing and of their being searched at the barrier before returning to their work, it was not altogether impossible that a match might have been inadvertently brought into the building. The difficulty in finding any other solution of the problem doubtless led to undue importance being attached by me to this cause, and there have been instances from time to time in which matches have found their way into danger buildings notwithstanding every precaution. But after careful consideration, I do not think it reasonable to suppose either (*a*) that a match accidently attached to a man's clothes could have been retained upon them for 3¾ hours while he was at work, or (*b*) that, had it fallen upon the table, it could have failed to have been seen by Curtis who was engaged in examining the sticks of cordite, before it arrived at the further side of the table, two feet distant, at which, according to the evidence, the flash originated. As the theory that a match dropped from one of the men's clothing would necessitate the reception of both of these suppositions, neither of which appears to be tenable, I am of opinion that a lucifer match accidently introduced into the building is not an explanation of the occurrence.

Nor could there have been a lucifer math or the head of a match accidentally embedded in the cordite in which the flash took place in course of the manufacture of the cordite. It would be superfluous to discuss this as a possible source of the ignition with those acquainted with the processes of the manufacture, but I may state shortly, that a match would be rendered harmless by the liquid nitro-glycerine mixed with the guncotton in which the match must have been contained, and that even if this were not the case, a substance as large as the head of a match would be excluded from the pulp of the cordite when it passed through the strainer of very fine gauze used to prevent foreign substances from going with it into the press.

Two further causes suggested themselves to me as possible explanations of the disaster. They are (*a*) heat caused by and (*b*) electricity generated by the friction of the sticks of cordite against one another or against the table.

As regards (*a*), cordite is an explosive which has always been considered peculiarly insensitive to friction. An ignition of cordite by rubbing one stick against another in the hands would be rightly looked upon as an impossibility. But, as in the present instance, the cordite had been rejected by the War Office for "sweating," it appeared to me that it was possible that some of the defective sticks which had caused the rejection of the consignment might have been in an abnormally sensitive condition; it was desirable, therefore, that experiments should be made with them in order to ascertain if this was really the case. They were first rubbed against one another, and then against rough wood at points where traces of exuded nitro-glycerine presented themselves, with no effect except that the temperature of the cordite, though sensibly raised by the friction, did not approach the igniting point; next, a stick was held against a rapidly revolving dry grindstone without any ignition; and lastly, a stick through which steel pens had been driven so that their points projected on the opposite side was held againt the same grindstone until the points were ground down, and there was still no ignition. I am, of course, aware that failure to reproduce an event does not conclusively prove that an event did not take place; but I think that in view of these drastic experiments, no one would venture to assert that the levelling of sticks of cordite on a table by a workman with his hand could by any possibility have brought about its ignition.

As regards (*b*), it is perhaps sufficient to show that cordite is a conductor of electricity, and that, unless insulated, it could not accumulate electricity in sufficient quantity to cause a spark to pass from one stick to another. To that end a stick which had been dried for 36 hours was rubbed upon fur which had before strongly electrified a piece of ebonite, without any electrification of the cordite being detected. This experiment was repeated several times with the same result.

But in addition further experiments have also been carried out to ascertain whether, if a spark could be made to pass, cordite or nitro-glycerine would be ignited by it. These experiments have been made for me by Captain Thomson, H. M. Inspector of Explosives, by whom also I was very largely assisted in the experiments previously referred to under (*a*). The result is thus summarised by Captain Thomson :—

"Fragments of cordite were placed in the direct path of the discharge of a powerful Wimshurst machine, the sparks having been slowed down by including a piece of wet string in the circuit; the cordite was not ignited. Under these conditions guncotton ignited somewhat readily. Cut cordite was then placed in ether together with pieces of calcium carbide to absorb the moisture ; nearly the whole of the nitro-glycerine was extracted by the ether, A thin piece of deal was thoroughly dried and heated, and in this condition it could be readily electrified. The wood was then soaked in the ethereal solution of nitro-glycerine, and the ether was driven out and the wood again warmed. In this condition it was impossible to produce any appreciable electrification. A silk thread which previously failed to conduct the current in the Wimshurst machine when steeped in the etheral solution and evaporated became an appreciable conductor. The board, impregnated with nitro-glycerine, was placed in the path of the discharge of the Wimshurst machine, and, though perforated by the discharge in many places, it was not ignited. Small pieces of cordite were found to be ignited by the discharge from an induction coil, but the discharge was so powerful as to exhibit nitrogen-flame, and on one occasion the heat of the discharge commenced to decompose the cordite without ignition."

Experiments on the electrification of cordite have also been made at the instance of Messrs. Kynoch Limited, the proprietors of the Factory. The summary of the results obtained will be found in a letter from them given in Appendix B.

In view of these results, and those obtained by Captain Thomson, the only conclusion is that, equally with heat, electricity generated by friction is not the true explanation of the ignition under consideration.

No other possible accidental causes have suggested themselves or have been suggested to me, and I am thus left without any reasonable probable explanation of this ignition, assuming that it was accidental. In these circumstances, I regret exceedingly to have to report that I am most reluctantly forced to the conclusion that the occurance was not accidental, but was wilfully brought about by some evil disposed person. Here again, I am beset with the difficulty that there was no evidence tending to confirm this view, and that I am, therefore, unable to conjecture who the person may be or by what motive he may have been actuated; but the fact that no motive is apparent is not a sufficient ground for rejecting what really appears to be the only explanation of the occurrence. As to the manner in which he may have accomplished his design it is unnecessary to inquire. Fortunately it enabled all of the three workmen to escape from the building.

I wish to add that I received every assistance from the manager and all connected with the factory in the course of my inquiry, and I beg to express my sincere sympathy with Messrs. Kynoch Limited in this misfortune which has befallen them.

I have the honour to be,
Sir,
Your obedient Servant,
A. FORD, Colonel,
H.M. Chief Inspector of Explosives.

The Right Honorable
The Secretary of State,
Home Department, S.W.

Appendix A.

[illegible]

[illegible] Date : June 24, 1890.
[illegible]
[illegible]

[illegible] The War [illegible] the amount of [illegible]

[illegible] Kynoch's factory near [illegible] on account of sweating. Brown, opaque sticks 23″ long and 0.28″ diameter. No appreciable amount of sweating perceptible. Heat test gives action in 25 minutes. It consisted of—

Nitro-glycerine	57.79
Nitro-cotton	36.84
Vaseline	4.92
Volatile matter	0.45
	100.00

(Signed) A. DUPRE.

Appendix B.

James Street, Haymarket,
London, S.W.
21st July, 1899.

Colonel Ford, C.B.,
H.M. Chief Inspector of Explosives,
Home Office,
Whitehall, London, S.W

SIR,

Accident at Thames Factory, No. 176, *Essex.*

I have the honour to inform you that a large number of experiments on the electrification of cordite have been carried out by ourselves and at the Mason College, Birmingham, and by Messrs. Marks and Clerk.

The following is a summary of the results we have obtained :—

(1). Cordite will not electrify by friction unless insulated, as it is a fairly good conductor.

(2). Cordite cannot be fired by discharge from an electrophorus, or from a Wimshurst machine, or even by discharge from a small Leyden jar. This applies to cordite in the form of sticks and in shavings.

(3). Cordite is fired by a short thick spark from an induction coil.

(4). When insulated cordite electrifies negatively when rubbed with silk, but it cannot be ignited by a spark drawn from it.

From the result of our experiments it appears impossible that the accident was caused by the electrification of cordite by friction.

I have the honour to be,
Sir,
Your obedient Servant,
(Signed) A. T. COCKING.

STRATEGY.

Strategical Railways.

Translated from the *Voiénnyi Sbórnik.*

The increasing importance of railways, not only within the respective countries, but in the case of the invasion of hostile territory, has led to their being almost universally subjected to military control, and moreover to the establishment of bodies of Railway Engineers, provided with the necessary material for constructing temporary lines for supply and other purposes on the enemy's ground. In Germany, even in peace-time, all matters connected with such railways as would be used in case of war come under the direct control of the Railway Department of the General Staff, presided over conjointly by a staff officer and a civilian expert. In war-time the control passes to the Chief Inspector of Field Railways, who is under the orders of the Inspector-General of Transports at Headquarters. In peace-time the Railway Engineers consist of the Prussian Railway Brigade, and a Bavarian Battalion. The brigade comprises 3 regiments of 2 battalions of 4 companies each, 2 being Saxon and 1 Wurtemberg, and is under the direct orders of the Chief of the General Staff; the Bavarian Battalion has 3 companies, and the whole 27 furnish cadres for the formation of new companies in war-time. The line from Berlin to Juterbog connecting the former with the practice grounds at the latter and Kumersdorf, is mainly intended for the training of officers and men in the practical working and construction of railways. A branch of the department is told off to watch the latest improvements in railway matters and to keep the engineers under instruction posted up in them, and also to make the necessary changes in the plans for mobilization. The department has charge also of all the *matériel* required, except that actually taken into the field by the mobilized companies, including the iron flying bridges, the construction of which is kept strictly secret. A large stock of plant for temporary lines has been laid in; that for munitions of war being much lighter than for other supplies, and the rolling stock is intended to be drawn by horses instead of engines. The gauge in both cases is 60 centimetres (about 2 feet).

In spite of the difficulties consequent on the political structure of the Empire, almost complete homogeneity has been secured. Moreover, in 1870 only nine lines were available for mobilization, whereas now there are sixteen with double gauge, and the Rhine can be crossed at twenty different points. As regards the eastern frontier, to which during the last ten years attention has been mainly directed, there are now eleven lines available, connected by cross lines running along the frontier. In 1870 the railway system had about 12,666 miles running, while in 1877 it was estimated at 30,828 miles, with 16,350 engines, or a total some two and a half times as large.

In France the strategical railways are controlled by the Chief of the Staff, subject to the supervision of the Minister of War. Here again a special section of the General Staff is told off to work out all problems connected with transport. The six principal railway companies and the State railways have a committee for military purpose consisting of an engineer in the service of the company, but subject to the control of the Minister of War, and a staff officer as military expert. There is also a central committee presided over by the Chief of the Staff, which includes the members of the lesser committees, a staff officer of artillery and one from the Minister of Marine, the Director of the Railway Department of the Ministry of Public Works, and two of his assistants—this is of course in peace-time; in war-time all railways pass under the control of the military authories, those in and about the seat of war being subject to the orders of the commander-in-chief, and the remainder under those of the Minister of War. The two zones are of course liable to change their limits as circumstances may dictate.

The Railway Engineers comprise 1 regiment (the 5th Engineers) and 9 bodies of Railway Pioneers. The regiment has 12 companies, besides conductors, each having a peace establishment of 4 officers and 100 rank and file. The men are trained by being attached to one of the railway companie for stated periods, in addition to which 6 officers and 100 men are permanently attached to the State line from Orleans to Charters. A telegraph battalion is in process of formation, its 6 companies comprising 168 non-commissioned officers and 432 men.

The bodies of pioneers are chosen from railway workmen liable for service, and have a military organization even in peace-time. Each of them numbers 1,273 men. In peace-time they have charge of all the lines not belonging to the six great railway companies.

As in Germany, the field companies have all the necessary equipment and *matériel* for the construction and working of temporary lines. There is also stored at Versailles the necessary plant for working short lines where tunnels have been blown up. There is said to be a sufficiency of *matériel* for laying down narrow-gauge lines of a total length of 400 miles. The gauge is the same as in the German light railways, 60 centimetres, and the trains are to be partly drawn by horse-power. There is also a large stock of iron flying bridges, especially of the Marsille pattern. When the war of 1870 broke out, there were only three lines available for concentration, with their termini at Thionville, Nancy, and Strasburg, and these for the most part single. Now there are ten, with double gauges almost through, independent of one another but connected by cross lines. Efforts are being made to still further improve the system so as to carry out the plan framed by Freycinet as long ago as 1879, by which each army corps should have a double.gage line for its sole use for the purpose of concentrating on the eastern frontier. Where the traffic is likely to be exceptionally heavy four lines of rails have been laid. Before 1870 France had 11,600 miles in working order and some 5,000 locomotives, while at the end of 1896 she had 28,000 miles and 11,000 locomotives.

In Austria-Hungary there is a Railway Department of the General Staff, the head of which in case of mobilization has control of the railway forces in the field and accompanies the Headquarters Staff. He then has charge of all arrangements for the transport of troops, the supply of *matériel*, and the construction of temporary lines on the enemy's territory, and the commander and two field officers of the Railway Regiment are on his staff. There is also a central railway committee in charge of the home railways, and the limits of its authority and that of the Director-General of Railways in the field are determined by the Minister of War in conjunction with the Chief of the Staff of the army in the field. The railway troops consist of a Railway and Telegraph Regiment, quartered at Korneuburg on the Danube and bodies of Railway Pioneers. The regiment is for instructional purposes under the Chief of the Staff, for administrative under the Minister of War, and consists on a peace footing of three battalions, each of 4 companies, and 2 cadres railway and telegraph respectively. These companies have 5 officers and 117 men in peace-time, in war 244 men, and a certain number of field and mountain telegraph detachments are also formed out of them. The Pioneer Corps, as in France, are composed of the regular *employés* of the railways, and have a captain, an engineer, 5 officers qualified as station-masters, and 200 non-commissioned officers and privates for station and traffic employment. Eight such bodies are registered in peace-time, but they are not assembled for training.

The Railway Engineers have the same field equipment as in Germany. Each company has its own transport, and is followed by a train. No special provision of material of the ordinary guage has so far been made, but it is said to be in contemplation; but there are stores of it for the 70-centimetre gauge, each of which contains 90 kilometres of line. Trials have been made under conditions as much like those of active service as possible, when from 50 to 60 kilometres were laid with complete success. As regards bridges, after many experiments with those of the Eifel pattern, the Minister of War has decided on those of Kon, and a large stock of these has been laid in. Men and officers are trained on the line from Bainakula to Doberlin, constructed at the time of the Bosnian campaign, and since retained by the military authorities. It is worked conjointly by the military and civil staft. The chief stress has of course been laid on securing facility of concentration on the Galician frontier. There are five lines leading to that frontier, and on these and the line from Oderberg to Lemberg all arrangements have been made for the rapid entertaining and detraining of troops, and the roads running from such stations as are some little distance from the frontier are kept in first-rate condition. A line has been run from Marmarosh to Ziegel and Stanislowo, and another from Menaosh to Strige, which have greatly improved the somewhat faulty communication with south-east Galicia. When these are open, seven lines will be available for concentration. In 1870 the total amount of miles in working order was 6,400, and at the end of 1896 it was 21,430, with 6,500 engines.

In Italy the railways are under the control of the Directors of Military Transports in peace-time. There is a special commission, under the presidency of the Chief of the Staff and his assistant, which has charge of all questions relating to the carriage of troops. The immediate responsibility rests, however, with the Railway Commissioners, under whom station inspectors are appointed at the principal stations. On orders being received for mobilization, the military authorities take over the control. A directorate is appointed, consisting of artillery and engineer officers of the General Staff, and representatives of the Inspector-General of Railways and of the chief railway companies, which for the time being forms part of the Ministry of War. Its orders are carried out by the working branches of the railway companies and the stations inspectors. As soon as the concentration is completed, the lines pass once more under the control of the respective companies, and the officers and officials of the various committees are attached to the Army Service Corps in the field.

The railway troops consists of :—1. The Railway Brigade. 2. Companies furnished by the railway companies. The brigade has 4 companies, 2 for construction and 2 for working, with an establishment on a war footing of 5 officers, 240 rank and file, 20 horses, and 5 wagons. The "constructive" companies are, by agreement with one of the railways, allowed to take part in the work of construction of that particular line. The others have charge to the traffic on the line from Torre to Pellis, 7 officers and 209 rank and file being constantly employed, but the administrative and organizing work is done by civilians. The four "constructive" companies supplied by the various lines are recruited from the *employés* of those lines who are liable for military service. Certain steps are taken in peace-time to form cadres for these. There are no stores worth mentioning of *matériel* or rolling stock. Experiments have lately been made with Eifel bridges and Decauville light lines.

Italy is greatly behind the other principal Powers in the matter of means of concentration. For reaching the northern frontier there are two main lines running the length of the Peninsula, one from Brindisi by Pescara and Ancona, and another from Reggio *via* Naples and Rome along the shores of the Adriatic and Tyrrhenian Seas. These and their branches connect the most important points in the plain of Lombardy, Novara, Milan, Verona, and

Venice. A comparatively rapid concentration is thus secured on the French and Swiss as also on the Austrian frontier. The passes of the Alps are so well fortified that there is no danger of the concentration being interrupted. During the last ten years new lines have been constructed, and additional sets of rails laid down, which has materially increased the carrying power of the two companies mentioned, while the numbet of cross lines enables troops to be gathered at any point of the littoral threatened. The railway along the shores of Sicily has also been greatly improved. There are now 10,000 miles running in the Peninsula, as against barely 4,000 in 1870, and 3,000 engines are in use.

—*Journal of the Royal United Service Institution*, October 16th, 1899.

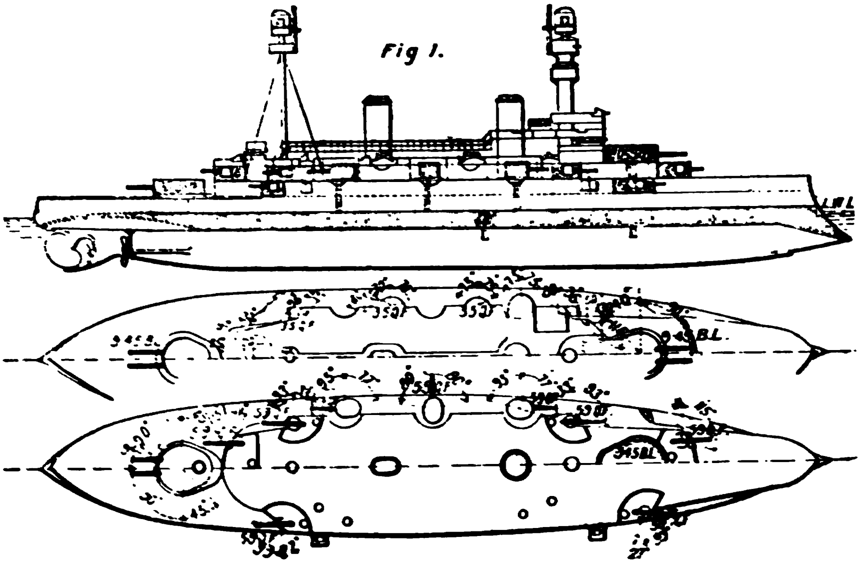
WARSHIPS AND TORPEDO BOATS.

The Launch of the Kaiser Wilhelm der Grosse.

We give herewith authentic photographs which we have of the *Kaiser Wilhelm der Grosse*, which was launched at the Germania Navy Yard, near Kiel, on June 1st last. This vessel is one of the group of three great turret ships building for Germany, namely, the *Kaiser Freidrich III*, *Kaiser Wilhelm der Grosse*, and the *König Wilhelm* (*Ersatz*). The table herewith shows the dimensions and principal data of the vessel in question. Fig. 1 herewith, copied from the *Naval Annual*, gives the structural plan; the thicknesses of the belt and turret armor, however, have been slightly altered in accordance with information received from Germany. It will be seen that the vessel is an extremely formidable first-rate line of battleship. The special features are great speed and energy of fire. In our judgment her protection is open to objection. At the same time only actual trial would test this. Her belt of 12-inch Krupp armor is abundantly strong, and with her curved deck protects her vital parts beneath thoroughly well. The upper structure has, however, very little protection beyond the actual gun positions, and could be riddled with common shell. The German contractors have accepted this liability, no doubt, making provision against serious fire by the removal of all wood. It would be interesting to see what common shell would effect. We question if the structure supporting the gun positions would not become injured and distorted by shell bursting beneath them, but to this the contractors no doubt have some reply. About the 18 knots speed there can be no two opinions. It agrees with what we have laid down for our largest 15,000-ton battleships, that is the *Bulwark*, *Implacable*, *Irresistible*, and *London*. The energy of fire is nearly as great as that laid down for any ship, that is. about 557,000 foot-tons per minute, or 53 foot-tons per ton displacement.

The first ship of this class completed was the *Kaiser Friedrich III*, which when tested at Wilhelmshaven on October 30th last easily made her 18 knots stipulated speed, with 13,500 indicated horsepower and 115 revolutions, although in a heavy sea and strong wind. It may be seen in the plan that the grouping of the guns and disposition of the armor is half French and half British. The belt is complete, and, as above said, the price is paid for it in absence of protection to the upper part of the hull. This, and the small single turret gun position on the broadside. are French. On the other hand, the curved deck and large double-gun turrets were originally British features, and some of the 15-centimeter quick-firing guns are in positions closely resembling Sir W. White's casemates. It is interesting to watch in the various designs of battleships the great uncertainty as to whether to adopt what we may term the French or British grouping. The French and British designers hold firmly to their own systems. No British ship can be found with her guns grouped in any sense like the French; we may look through our designs in vain for the little single-turret mountings. No French ship has anything like our casemates. This distinctive line is rarely found in other navies. Russia was apt to surround her secondary armament with a single-armored wall, with a marked absence of steel traverses and divisions, but in the *Poltava* class the heavy quick-firing guns are in small double turrets. The newer Japanese designs are distinctly British, except that in the *Mikasa*, building at Barrow, of 15,200 tons displacement, the largest battleship in the world, the quick-firing gun casemates have no intervals between them, thus forming a continuous wall, for which, we think, there is much to be said. The United States armaments have been grouped rather on the French system, while the armor, forming a belt of limited length in combination with horizontal armor at the ends and the side plates over the belt, is British. Germany has followed France in the complete water-line belt and grouping of armament generally, although in this class we now see some approach to the British casemate and the curved deck.

Fig 1.



THE KAISER WILHELM DER GROSSE

Finally, we may remark that the *Kaiser Wilhelm der Grosse* class marks the existence in service of the Krupp thick armor, which has given the remarkable results that have caused the adoption of this armor in all important navies. It was with this class of plate that Krupp obtained the record figure of merit of 2.331; that is to say, a resistance equal to that of 2.33 times the plates' thickness in wrought iron, so that the ship's 12-inch, or possibly 11.8-inches of Krupp steel may be equivalent to about 28 inches or 27.5 inches of iron. As our readers are aware, the German navy is likely to be increasingly furnished by Krupp.

KAISER WILHELM DER GROSSE, GERMAN FIRST-CLASS BATTLESHIP.

Length	377 feet
Beam	67 feet
Draught	26 feet
Displacement	10,955 tons
Motive power	13,000 H.P.
Speed	18 knots
Coal supply	640 tons

Armament:

4	24 cm. (10-inch)	Quick-firing guns
18	15 cm. (6-inch)	
12	8.8 cm. ($3\frac{5}{16}$-inch)	
12	3.7 cm. ($1\frac{15}{32}$-inch)	
8	0.8 cm. ($\frac{5}{16}$-inch)	Machine guns

Torpedo armament:

1	under-water bow tube	53 cm. (21-inch)
4	" broadside tubes	46 cm. (18-inch)
1	above-water stern tube	46 cm. (18-inch)

Armor:

Belt	12 inches
Curved armor deck	3 inches
Conning tower	10 inches
Turrets for the 10-inch guns	10½ inches
" " 6-inch guns	6 inches
Casemates	6 inches

—*The Engineer*, July 7, 1899.

MISCELLANEOUS.

Chemistry and War.

The venerable Franklin Institute of Philadelphia celebrated its seventy-fifth anniversary on Monday, October 2, and the November number of the *Journal* contains several of the interesting addresses delivered on that occasion. Harvey W. Wiley, Chief Chemist to the United States Department of Agriculture, discourses very learnedly and very interestingly on the subject of the relations of chemistry to the advancement of the arts. Among the other arts profiting by chemical research is the art of war. In this department, as Mr. Wiley tells us, these researches have been devoted mostly to the elaboration of more powerful explosives. In ancient times, before the invention of gunpowder, battles were fought by the actual coming together of the participants. There was added thus to the horrors of war the bitterness of personal conflict. Modern warfare is almost wholly removed from the possibilities of battle by personal contact of soldiers with the enemy. Thanks to chemical science, those who engage in battle are constantly widening the line between the two opposing armies, so that a modern battle is rather a test of chemical skill than a trial of physical prowess. Little by little chemical research has invented means for carrying projectiles further and with greater destructive force. These advances have been met by a recession of opposing forces, so that in point of fact the destruction by battle is decreasing rather than increasing with the invention of better explosives and improved firearms. One hundred years ago a naval battle was not thought to be complete unless the two opposing ships came into actual contact, and the victors boarded the vessel of the vanquished. The slaughter in such cases was something frightful. In our last naval war, armored vessels, securely riding the sea at a distance of one or two miles from the enemy's fleet, proceeded to the bombardment more as if performing an evolution than as if engaging in actual battle. As a result of the application of chemical science combined with mechanical skill, the victors in the two great recent naval battles scarcely lost a man, and the sailors of the defeated vessels were quickly picked up and preserved by their conquerors. The dictates of humanity require that if a war is to be fought, it should be short, sharp and decisive. Chemical invention has rendered it possible to bring a war, great or small, to a speedy close, with an aggregate saving of human life, so that even in the destructive arts and industries chemical science has done much, not only in the accomplishment of speedy results, but also in the conservation of human life.

When it comes to the care of the wounded, chemical science again claims a share of the glory. The antiseptic treatment of wounds is due solely to the study of the causes which formerly made wounds so fatal. At the present day if the skilled surgeon can reach the wounded man in time, unless the actual loss of tissue is so great as to bring about a fatal result, the sufferer can be saved The inflammation and the gangrene which have caused the deaths of so many soldiers after the battles of the past are now practically unknown in the light of modern chemical surgery. Chemistry has furnished not only the theory on which the antiseptic treatment of wounds is based, but the material which makes it possible. * * *

"Life at best is but a battle, and war, after all," Mr. Wiley says, "is the normal condition of mankind. It was the struggle for existence that first brought man from the level of the lower animals to have dominion over them. It was the battle of one tribe with another that enabled the superior race of men to people the earth. It is struggle with his enviroment that develops the power and the precedence of the successful man. While deploring the horrors of war, the sober student of science must admit that it has its uses. Not only does war and struggle bring power and dominion, but it brings also responsibilities and duties which science will show man how to meet and discharge."

—*Army and Navy Journal*, November 25, 1899.

BOOK REVIEWS.

A French-English Military Technical Dictionary. By Cornélis De Witt Willcox, First Lieutenant of Artillery, U. S. Army. Washington. Government Printing Office. 1899. War Department. Adjutant-General's Office. No. XXIV, Part I.

The necessity for a French-English Military Dictionary for the use of English or American military students cannot be questioned, and this particular one fills a want because there is no other that is sufficiently comprehensive and at the same time recent. The meaning of technical words changes at a rate proportional to the rate of progress in the sciences, and the number of new words introduced in a language varies according to the same rate.

The author, educated as he was at a French school in his childhood and youth, trained and educated at the Military Academy, with the further experience of an instructor in languages at his *alma mater*, and with a decided natural bent for literary work, came to his task well-equipped, full of enthusiasm and generously supplied with material derived from reading and study.

The present volume, Part I, comprising the words from *A* to *espace*, covers 160 octavo pages, so that the number of words considered is far above that of any similar dictionary. The utility of such a work to the army is a sufficient reason for its publication by the War Department, but it is nevertheless gratifying to see that the War Department is willing to encourage such labor by giving it an official stamp of approval.

It is impossible to make a dictionary of this kind absolutely perfect, but the author has evidently had access to the best and latest French military publications, so that his work should be fairly comprehensive and entirely modern, and as he is able and consciencious his task should have been well accomplished. The paper and print are all that could be desired, and the entire work will form an elegant as well as a useful volume of reference.

J. P. W.

The Hygiene of the Soldier in the Tropics. F. Burot and M. A. Legrand. Translated by Captain George W. Read, 9th U. S. Cavalry. International Series No. 7. Kansas City, Mo.: Hudson-Kimberly Publishing Co. Pp. 211. $1.50.

This interesting volume, constituting No. 7 of the International Series edited by Lieut.-Col. A. L. Wagner, is the result of the experiences of the French army in Madagascar, Tonkin and Martinique; and the object of the translator is to make these experiences useful to our own troops in Cuba, Puerto Rico and the Philippines.

The first subject taken up is that of sites for posts or garrisons, and the construction of barracks and quarters. In this chapter particular emphasis is laid on the fact that, although high ground is generally preferable to low, it is not always the most hygienic (especially when certain diseases like dysentery are prevalent), nor is it always possible to select high ground. When low ground must be accepted care should, however, be taken that the subterranean water is more than a yard below the surface. In the construction of quarters and barracks attention is called to the absolute necessity for porches and galleries where (in a southern climate) the troops spend most of their time. Even within the limits of the United States proper, all barracks and quarters at southern posts should undoubtedly have generous piazzas, and galleries on the upper floors, and in tropical climates such arrangements are absolutely required.

The question of the proper ration is next considered and it appears that, as "the soldier in the tropics is always in campaign, if not against the enemy, at least against the climate," his ration should be (as a standard) at least:

750 grams fresh bread.
500 grams fresh meat.
120 grams dried vegetables.

Attention is also called to the fact that the best food to give the soldier is that which is the most easily digested and assimilated, because the digestive organs become languid, and therefore they should not be made to do too much work.

Clothing and equipment receive attention, and a point is made of wearing linen trousers by day and flannel by night. As regards the military life of a soldier it is held that "from ten o'clock in the morning to four in the evening, all outside drills should be prohibited."

Under medical service questions relating to medical officers, nurses and hospitals are considered, and the subject of hospital transports is fully discussed.

The entire work is well worth thorough study not only by the officers of the Quartermaster's and Medical Departments, but also by every officer of the line, since it is founded on experience and presented by men competent to speak on the subject, and its lessons find daily application in our military life, particularly in our new possessions.

J. P. W.

Construction der Gezogenen Geschuetzrohre, von Georg Kaiser, K. und K. Hofrath, Ord. Professor. mit 14 Figuren-tafeln. *Zweite*, umgearbeitete Auflage. 1900. Wien : L. W. Seidel & Sohn.

Professor Kaiser's work is a complete compedium on the science of gun construction. The first edition appeared in 1892, but the great progress in fire-arms of all kinds during the past seven years, largely due to the introduction of smokeless powder rendering possible the high initial velocities of to-day, has necessitated a complete revision of this earlier edition, and no pains have been spared to make this work a standard of reference for the theory and practice of gun construction in general.

After a brief discussion of the necessity for different calibers of guns, and a description of the various kinds, and their special applications, the author takes up the subject of rifling, discussing in turn the four principal old pressure, button, expansion and polygonal systems. The modern system is introduced by a preliminary consideration of the interior ballistics of a gun barrel. The main part of the work consists of chapters on modern rifling, the theory of the strength and elasticity of hollow cylinders, the theory of built-up guns, metals for gun construction, gun construction proper from the first cast-iron to the latest wire-wound pieces, and finally breech-blocks of all kinds.

The work closes with interesting notes on the determination of the weight and the center of gravity of a gun, and of the dimensions of the trunnions, and the mode of procedure in calculating the dimensions of a gun of a particular caliber, with a given weight of projectile and a definite initial velocity, as well as the methods employed to determine the dimensions to be given to armor-piercing and ordinary projectiles.

The text comprises 419 printed pages, while the accompanying plates are fourteen in number, with a mass of figures accurately drawn to scale, clearly showing all the details of construction.

The author has devoted many years of his life to the subject he discusses, and he has produced the most complete and accurate treatise on gun construction extant.

J. P. W.

Strategisch-taktische Aufgaben nebst Loesungen. H. v. Gizycki. Leipzig: Zuckschwerdt & Co. 1897. Heft 5, 3 Marks: Heft 6, 1.50 Marks.

This excellent collection of strategical and tactical studies, now in its fifth edition, has been so generally praised, not only in our colums, but also by the principal military periodicals, that further comment appears unnecessary. We recommend the entire collection of twelve numbers as undoubtedly the best aid to the study of strategy and tactics known.

Number 5 discusses the actions and movements of a division protecting the left flank of an army, and contains twelve separate problems in strategy and tactics, with their solutions.

The general situation of the army and the division considered, as well as of the enemy, so far as it is known to the division commander, are given. Then follows the first problem, viz.: the occupation of a large town by a flank detachment (1 inf. regt., 1 cav. regt. and 1 field battery), and the reconnaissance of the ground towards the enemy. Problem 2 considers the instructions to be given to a reconnoitring force of 1 battalion and 2 squadrons sent out to clear up the ground and destroy the railroads at the points to which the enemy is liable to bring his troops by rail. The third problem discusses the preliminary measures taken by the commander of this force in executing his orders, the fourth treats of his decision and action when he learns where the enemy proposes to unload his troops, and the fifth his advance to meet the incoming reports from his advanced patrols.

The sixth problem involves the advance of the entire detachment to support the reconnoitring force, the seventh the decision of the commander of the reconnoitring force to drive the enemy from one of the points of debarkation occupied by him, while merely observing the other, more strongly held, point. The eigth problem contains the further orders of the detachment commander for the general advance against the enemy, and the ninth discusses this advance in detail.

The tenth problem discusses the action of the commander of the reconnoitring force at the point captured from the enemy when the latter, after debarkation at some point farther to the rear, advances in force, viz: retiring to a point better suited for defence.

The eleventh problem is taken up with the preparations for attack, and the twelfth sets forth the battle which resulted.

The entire number comprises about eighty pages of printed matter, to which are appended an outline sketch of the country and two detailed maps

Number 6 contains general considerations on the problems thus far discussed, the elements of accident and luck in war, the fact that the result of a battle is not determined by the absolute amount of work of the winning side but by the relative amount of both sides, and many other points of interest, comprising about sixty printed pages.

J. P. W.

Aids to Scouting. Bt. Colonel R. S. S. Baden-Powell, 5th Dragoon Guards. Aldershot : Gale and Polden Ltd. One shilling.

This little book by Colonel Baden-Powell, who is now besieged in Mafeking, is very readable, and contains many valuable hints for the most arduous of military duties. The author is evidently devoted to the subject, interested in the work and full of enthusiasm as to its possibilities. He has had interesting experiences himself, and has studied those of others; moreover, he has evidently taken up scouting as a sport, with an Englishman's love for the latter.

The work not only instructs, but inspires the reader with a desire to learn, which is often a most important factor in instruction, and will be found useful by all military men.

J. P. W.

History of the Manufacture of Armor Plate for the United States Navy. Compiled by the American Iron and Steel Association. Philadelphia : The American Iron and Steel Association, No. 261 South Fourth Street. 1899.

The American Iron and Steel Association has issued a most interesting pamphlet of about 13 printed pages, setting forth the history of armor plate for the Navy, particularly as regards the action of Congress and of the Secretary of the Navy, from the first contract made by the Navy Department with the Bethlehem Iron Company on June 1, 1887, to the present time. The pamphlet is beautifully illustrated by reproductions of photographs of our most interesting warships, of armor plates, and of the works of the Bethelem Steel Company.

J. P. W.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

Historischer Rückblick auf die Verpflegung der Armeen in Felde. III. Lieferung. Oberst Otto Meixner. Vienna : L. W. Seidel & Sohn. 1900.

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INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

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Aldershot. Copies 6*d each.*

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7 *s.*

Army and Navy Gazette. [*A. and N. Gaz.*] *Weekly:*
3 *York Street, Covent Garden, London. Per year* £1 12 *s* 6 *d.*

Canadian Military Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

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33 *Norfolk Street, Strand, London. Per year* £2 6 *d.*

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Journal of the Royal United Service Institution. [*Jour. R. U.S.I.*] *Monthly.*,
22 *Charing Cross, Whitehall, London, S. W. Per year* 24 *s.*

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66 *Russell Square, London.*

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169 *Queen Street, Melbourne, Australia. Per year* 11 s. 6 d.

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5 *Adelphi Terrace, London, W.C.*

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10, *Wine Office Court, Fleet Street, London, E. C. Per year £*1 10 *s* 6 *d.*

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13 *Charing Cross, S. W. London. Per year* 27 *shillings.*

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3 *Place du Théatre Français, Paris, France.*

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6 *Rue de la Chaussée d'Antin, Paris. Per year* 45 *Fr.*

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26 *Rue de Grammont, Paris. Per year* 30 *Fr.*

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6 *Rue de la Chaise, Paris. Per year* 8 *Fr.*

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258 *Calle Montevideo, Buenos Aires, Argentina. Per year* 10 $ $\frac{m}{n}$.

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5 *Calle de Cervantes, Barcelona, Spain. Per year* 32 *Fr.*

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27 *Rua Nova do Almada, Lisbon, Portugal. Per year* 1 $ 800 *reis.*

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MARCH—APRIL.
Vol. XIII. No. 2. Whole No. 41.
1900.

JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED UNDER SUPERVISION OF THE

STAFF OF THE ARTILLERY SCHOOL.

ARTILLERY SCHOOL PRESS,
FORT MONROE, VIRGINIA.

[illegible]

UNITED STATES ARTILLERY SCHOOL,

FORT MONROE, VIRGINIA.

The *Journal of the U. S. Artillery* is published at the Artillery School as a bi-monthly, by authority of the Staff of the School

COMMITTEE OF DIRECTION AND PUBLICATION.

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Subscription	$2.50
For countries in the postal union	$3.00
Single numbers	$0.50

Remittances should be sent to the editor at Fort Monroe, Va.

AGENTS.

NEW YORK—*Dyrsen & Pfeiffer*, successors to
F. W. Christern, 254 5th Avenue.
LONDON—*B. F. Stevens & Brown*, 4 Trafalgar Square.

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JOURNAL OF THE UNITED STATES ARTILLERY.

VOL. XIII. No. 2. MARCH—APRIL 1900. WHOLE No. 42.

LIGHT ARTILLERY.

PRACTICE MARCHES AND CAMPAIGNING.

The object of practice marches* may be summed up in the one word "experience," as affecting officers, men and horses; and, in a certain sense of the word, matériel.

Such experience finds ready application in the field of active operations; and incidents of *practical* as well as practice marches are included in this essay.

PRACTICE MARCHES.

In the writer's several such marches the average distances traveled were, in California about 16 miles, and in New England and Kansas about 19 miles a day.

The former of these was made in that portion of the coast range known as the Santa Cruz Mountains, extending along the coast from San Francisco 90 miles south to Santa Cruz, and then back across the range into the Santa Clara valley. All the marching in the mountains was over ordinary country roads; in the valleys, over macadamized turnpikes.

The first march in New England was made with Light Battery "B," 4th Artillery, from the Berkshire Hills to Worcester, Massachusetts, and thence through the whole length of Rhode Island from north to south. Part of this march was over country roads and part over macadamized turnpikes. In both cases mountains were crossed at from 800 to 1000 feet above the surrounding country.

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* A short article by the writer appeared in the *Journal of the Military Service Institute* for July, 1886. It was entitled "Practice Marches of Light Artillery;" it had been written for and read in the Lyceum at Fort Adams; and it was published at the request of the editor of the *Journal.*

Increased experience has been gained at the Fort Riley Light Artillery School, in camp at Fort Tampa and in the lines before Santiago de Cuba and the writer is induced to recast the original article for the *Journal* of the United States Artillery.

The second march in New England was made from Fort Adams, R. I., to Cape Cod, Mass., over roads comparatively level and in some parts sandy. This was in the months of August and September, 1896. The camps were good, water was fine and fuel was plentiful.

The weather was very hot, but the neighborhood of the ocean spared men and horses from suffering. The battery averaged about 15 miles a day; the longest march in any one day being 28 miles.

During the months of September and October, 1897, the battery, with four troops of the 2nd Cavalry and seven wagons, made a march from Fort Riley to Fort Leavenworth and back.

This was in the valley of the Kansas River, for seventy odd miles, as far as Topeka; then northeast across ridges separating the Kansas and Missouri rivers. The roads run, as a rule, on township lines, north and south, east and west.

This, a part of the so-called "Golden Belt" of Kansas is the most fertile region on the globe, and is noted for its yield of corn and fine fruit. Deep "driven wells" strike a good water bearing stratum; but fuel is scarce and trees are found only along streams. The weather was very hot during September and early October, and the roads dusty; but on the return march to Fort Riley it was quite pleasant and the horses stood the trip well.

In the *practical* (rather than "practice") march of the batteries of the Light Artillery Brigade from Baquiri to Santiago de Cuba, two only of the six batteries* succeeded in getting into the trenches enveloping the city, before its informal surrender on the 14th of July. The Spanish Commander Linares, in his official report of July 12th, refers to "a fearful storm of rain which has been pouring continuously for the last 20 hours." This down-pour left the roads in such a condition that although we had dropped the caissons along the route of march and had hitched all teams to the guns it was at times almost impossible to get on. The guns and carriages sank to the hubs of the wheels in mud ; a mud incomparably worse than that encountered any where in the United States.

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* This refers to the reinforcing batteries of Randolph's Brigade which arrived in Cuba, July 9th.

Captain C. D. Parkhurst, 2d Artillery, in referring to these batteries Taylor's of the 4th Artillery and Reilly's of the 5th Artillery, says:

"Began landing Sunday, July 10th, at Daiquiri.

Finished landing and left Daiquiri 12 m. on 13th, leaving behind five caissons, and battery wagon, with small detachment in charge.

Bivouacked in road at Seville night of 13th.

Arrived at Shafter's headquarters 8 a. m. of 14th.

In position right of Capron's battery 9.45 a. m., 14th.

Could have gone at once. Got orders not to dig that day. On 15th orders came to dig gun pits, and get ready in case of any hitch. Remained in position until 17th. Went into camp at Caney after this. Reilly's battery had practically the same experience; had position away on the right. Both of these batteries were full six-gun batteries.

We thus see that before June 17th there were in all four four-gun batteries, two six-gun batteries, or twenty-eight 3.2-inch field guns, and eight 3.6-inch field mortars in position in front of and surrounding Santiago de Cuba. No siege guns nor siege howitzers or mortars had been brought up."

Officers.

Experience on the march as it relates to the officers includes in general everything, but applies more particularly to information regarding the military characteristics of the country passed through, to selection of sites for camping with suitable watering places, and to ascertaining practically what work is to be expected from horses under various conditions. Where the country is rough and unsettled this experience is of special value. Maneuvering over unfamiliar ground, with target practice at undetermined ranges, is also an essential feature of the practice march.

A knowledge, from a military point of view, of the topography of the country passed through on the march, can be obtained by observation alone. The ordinary county maps which supply the only available information, leave much to be desired, and are inaccurate except as to the location of main roads and streams. Maps of the Coast and Geological Surveys have been published by the Government, but these unfortunately cover only a small area of territory.

To select sites for camping is not difficult as a rule ; the important requisite being a suitable space for the picket line, with water near at hand for the horses. A camp so provided can be used no matter what may be its other disadvantages. If the camp is to be occupied for any length of time, great care with regard to details is necessary in its selection ; and all suggestions in Drill Regulations should be followed as closely as circumstances permit. During the march the battery officers usually ride ahead of the battery and fix upon the camp site. This duty devolves upon the subalterns, each in turn.

As regards the working capabilities of a horse : if the country be comparatively level and the roads good, a battery may average on the march from 20 to 25 miles a day and the horses arrive in camp in good condition. If the roads, however, are such as one usually finds in the United States, except in the more thickly settled sections, 20 miles may be considered a liberal estimate.

In all the marches except those made in California, drills and target practice were kept up. The drills were, of course, very much restricted owing to the nature of the ground; but in moving in and out of camp and in target practice frequent opportunities were afforded to test the maneuvering possibilities of guns and caissons.

The transportation of batteries by rail and sea, when marches were impracticable, will be considered farther on, under the heading "Campaigning."

Enlisted Men.

What has been said concerning the officers applies as well to the enlisted men, and especially to the most intelligent who are likely to become officers of volunters in time of war. There are many things that they may learn on the march, as for instance, how to get the best work out of the animals with the smallest waste of strength, the method of overcoming obstacles, of crossing bad bridges, of helping carriages and teams that get into trouble, and of watering, feeding, and caring for horses under different conditions than those of the garrison.

As regards the men personally, they learn how to take care of themselves when "roughing it," and to disregard trifles. A trip of this kind enables them to realize that the life of a soldier calls for other things than mere garrison duty. The most important lesson for the soldier, as for the officer, is the maneuvering of his gun at drill on unfamiliar ground and at target practice. He is taught by these exercises to know just how much reliance may be placed on the gun, when used against an enemy. A liberal allowance of ammunition with frequent practice is most desirable as establishing confidence and increasing the interest of the men in their profession.

Materiel.

Having thus briefly considered the effect of experience upon men and horses, we now come to experience in the matter of matériel.

The word *test* may be more appropriately used in this connection. The test is the more valuable, in proportion as the country passed through is rough and varied.

Such tests may be considered in the following order:

First. On the roads in the actual march.

Second. When maneuvering over unfamiliar ground for purpose of drill or target practice.

Third. When actually firing with service ammunition and simulating as nearly as possible the conditions of the battlefield.

Although all of these tests are important, the third has the greatest significance. The first applies to all vehicles alike, the second to the guns and caissons, and the third more particularly to the gun carriages. Observations under the second and third heads are entered under the heading, "Target Practice."

If the roads are hard, well macadamized and tolerably level, a battery can generally march along at a good walk, and the supply wagons keep well closed up to the rear of the column. As soon as rough roads are encountered or a mountainous country is entered there is a tendency of the column to lengthen out and straggle, the guns and caissons leaving the supply train behind.

Limber and caisson chests should be full of ammunition, and the carriages provided with everything they are expected to carry in time of war, in order that the load may be the maximum. Team and carriage will then do the utmost work that can ever be required of them, and develop weakness and defects at a time when they can be remedied.

On the march in California the train consisted of five army escort wagons, drawn by teams of four mules each. On the marches in New England the train consisted of a wagon manufactured by the Ordnance Department, and a heavy spring wagon with high body and low wheels, such as is used for heavy trucking in cities, these two being drawn by spare battery horses. The difference in result was greatly in favor of the army mule and escort wagon. In the first case there was not a single delay caused by the train, which was always well closed up in rear of the column ; so that on arrival in camp no time was lost in waiting for mess kits. In the New England marches there were frequent delays, and on steep hills, teams from guns and caissons had to be sent to the rear to help the spare horses bring up their too heavy loads. Further than this, in order to prevent the spare horses being used up, they were frequently replaced by teams from guns and caissons.

Preparation.

There should be no preparation for these marches other than that which the regular garrison routine affords. That is to say, the battery should at all times be prepared to take the field. The best method of testing efficiency would be to have the battery commander receive, without warning, orders allowing him a limited time in which to make preparations and establish himself in camp at a previously designated place some days march from the garrison. The battery should then be thoroughly inspected by a qualified officer, one whose experience would guide him in making such an inspection.

Certain officers not otherwise employed, might go over the route which is to be followed in order to obtain supplies and information, and in a general way, perform practically the duties defined in various works on the Art of War.

Under our present system, a practice march usually originates with the battery commander, and is preceded by a correspondence between him and his superiors.

During this correspondence, the horses are what is technically termed "hardened" for the trip, by daily marches over any available roads near the post, the distances being increased from day to day until they cover as much ground as is to be expected of them. To a certain extent this harderning must *vitiate the test*, since if an emergency arise, and the horses be not already "hard" there is little or no time for the process; and a battery may be so crippled by several days marching, under unexpected orders, as to be useless at a time when its services are in urgent demand.

Target Practice.

The target practice of Light Battery "B," 4th Artillery, at Tyringham, Berkshire county, Mass., 1895, and at Barnstable, Mass., 1896, may be briefly described.

At Tyringham a very suitable spot was found on the top of a broad plateau between the Housatonic River and Hop Run, about 1800 feet above the sea. The target was set up on the cleared summit of a gently sloping hill; and from the ridge on the opposite side of the valley we were able to get ranges of from 1000 to 2500 yards; firing over a wide swampy bottom covered with a heavy growth of small trees and underbrush. The firing points were in fields that had formerly been cultivated, but had been lying out long enough for a considerable growth of brushwood and trees to appear, thus affording a good opportunity for testing the maneuvering capabilities of the gun on rough ground. The recoil was very much diminished by this state of things, being seldom as much as six feet. This resulted in developing the structural weakness of the steel carriages; and it was found after practice that the axles of all four were so much sprung as to necessitate replacement by others. The stiffening plate had failed to support the axle in the manner intended. The other parts of the carriage behaved well during the test; though after firing several rounds and breaking through the turf the trail would bury itself in the ground.

The full allowance of ammunition was used, 20 shell, and 80 shrapnel, all being fired with the service charge 3½ pounds of powder. The general plan was to use the shell to find the range, and then the shrapnel, to do as much damage as possible to the target.

The practice occupied two days, 50 shots being fired the first day, at range of about 1500 and 1800 yards; and 50 shots on the second day, at about 2300 yards. The ammunition was thus divided because there were only three practicable firing points.

The weather was bright and warm, the air clear and dry. A light wind which grew quite strong during the firing, blew across the range on the first day. There was almost a calm on the second. During the first day an observer was posted on one side of the target to correct errors in establishing the range and to signal when it was correctly determined; after which firing with shrapnel was had under battle conditions, each gunner, without supervision, handling his own piece. The observer's signals could be read only at the shortest range. At 1800 yards, on account of the small flag and the background, they were so difficult to make out, that, on the second day, no such attempt was made, and observations at the firing point were relied on. All shells were fired deliberately, and a few of the shrapnel; but at each range, after deliberate fire, the firing at will took place and as follows: at 1500 yards, 16 shrapnel in 12 minutes; at 1800 yards, 12 shrapnel in 13 minutes; and at 2300 yards, 25 shrapnel in 29 minutes.

The results of the firing were, on the first day, about 1200 hits, and on the second about 500, some six or eight of these being shell or shrapnel that passed through the target before bursting.

At Barnstable, Cape Cod, Mass., in September, 1896, three targets were set up on the sand pits to the north of Barnstable Bay, from one-half to one mile east of the lighthouse.

The targets were built of boards to represent an infantry skirmish line, a column of fours, and a platoon of light artillery in action. The battery went into position on a bluff overlooking the bay, about 3500 yards from the nearest, and between 4000 and 4300 yards from the other two targets, respectively. It fired over water with shell to find the range, and with shrapnel to produce effect. The combination fuzes worked well and the shrapnel was so effective, that a column of fours would have had to deploy as skirmishers at 3000 yards and "take cover."

The target practice at Fort Riley was frequently made with movable targets representing mounted men, the targets being dragged across the firing range, at a walk, at the trot and at the gallop.

In every instance the shrapnel was very effective and the fuzes worked admirably.

Campaigning.

In the spring of 1898, the ten light batteries of the old regiments of artillery were concentrated at Chickamauga, Ga., under the command of Brigadier General Wallace F. Randolph. The organization was designated, later, the Light Artillery Brigade of the Fifth Army Corps.

Three of these batteries, (to one of which the writer was attached), set out from the Light Artillery School at Fort Riley, Kansas, on the night of March 16, 1898; and from that time to the close of the late war were engaged in field operations.

The transportation within the limits of the United States, to the date of arrival at Port Tampa, Florida, was in most cases by rail; and, later on, by sea, to Cuba.

Two of the batteries were in position in the trenches at Santiago de Cuba before the surrender, and the third, proceeded from Baquiri, to Porto Rico.

Transportation by Railroad.

The gun carriages and wagons are usually carried on platform cars, on coal gondolas or in box cars. When platform cars are used (as has generally been the case within the observation of the writer) pieces of scantling (3 x 9 inches) should be spiked to the standards. Thus arranged the cars are entirely suitable and are superior to all others on account of the facility with which they can be loaded or unloaded.

With the sides of the platform removed, the whole length of the car becomes available, and the carriages can, if properly chocked, be as well secured on the platforms as on the gondolas. The gondola or flat bottom coal car with its fixed sides, from two to three feet high, is well adapted for the transportation of the carriages and wagons; but, owing to their construction, they must be loaded or unloaded from the end. This necessitates the removal of the brake hand wheels The intervals between successive cars should be bridged over. When the three light batteries were shipped from Fort Riley, Kansas, to their several destinations at the outbreak of the war, this method was adopted.

Caissons and full limber chests require to be run over the length of several cars, and the gondola is for this, as well as other reasons, unsuitable for the transportation of artillery carriages.

The high sides of the gondola make it difficult for the men to work at the wheels of heavily loaded caisson bodies, and there is risk of serious injury, should they be crowded against the sides.

If the gondola must be used, as was the case in the move from Fort Riley, care should be taken to chock the carriage wheels. The same difficulties are encountered in unloading as in loading these cars; and in either case sectional picket lines with all other available rope should be used to lash the poles, spare wheels, and other parts.

The exposure of the battery outfit to fire from cinders can best be avoided by placing the cars as far as practicable from the locomotive. The paulins, which themselves are quite inflammable are no safeguard for the woodwork of the carriages, unless well sluiced with water.

Box cars, of the kind used for the movement of furniture, could be advantageously employed for the transport of battery carriages. As cars of this class, however, are in constant demand for carrying army supplies, they should not be counted upon for transportation of light artillery. If horses are to travel by rail the greatest care is required in order that the animals may arrive at the journey's end in fit condition for immediate service in the field and for this reason more than any other, the men should be kept sober and watchful of the teams.

"The Arms" and "The Burton Palace Car," are superior to all others for the transportation of horses.

In either of these the horse stands in his individual stall and can be watered and fed without difficulty. "The Arms" pattern is similar to the large size box car, although somewhat longer. It has a maximum capacity of eighteen horses; nine in either end with a space in the middle between the doors. Nine horses of one row stand abreast, facing in the same direction and diagonally opposite the nine in the other row. A feed trough passes along under the heads of each row and in it a man can walk when feeding and watering the animals. Through a window in the end of the car and in line with the trough he can pass from car to car, whether the train be at rest or in motion. The floors are cleated to furnish a foot-hold ; the partitions are of heavy plank, hinged at the front end and securely locked at the rear. In loading, each horse is successively placed and his partition closed before the next one is let in. A heavy swinging bar hinged in such manner that it can be let down and braced within a few inches, but above the rumps of the horses, prevents their kicking over the partitions. The height of these is about four feet. A wire gauze ventilator is carried around the top of the car near the roof. Since the horses are placed in diagonally opposite ends of the car there is a very noticeable upward rise and downward sag, which strains the car and gives it a warped appearance, When traveling at high speed a very unsteady motion results from lack of symmetrical placing, and this is undoubtedly a source of discomfort if not of danger to the animals.

"The Burton Car" provides for sixteen horses. It is equally divided by a transverse partition reaching nearly to the roof. Eight horses, standing four abreast, are accommodated in either end and in fixed longitudinal stalls, tails out, each stall being provided with a "feed box." The car is ventilated as in the "Arms" pattern, and a man can pass through by climbing over a partition and out of a window at either end. It has four side doors each half way between the middle and end of the car. It seems to have more advantages and fewer defects than any other form of car for horses. The load is evenly and symmetrically distributed, making the car run to better advantage than any other style of horse transportation car. The stalls have high fixed sides which obviate the danger of horses kicking over or knocking loose the fastenings. From the way the horses stand, they cannot be thrown off their feet by a jerking start, and they are so arranged as to prevent them from rubbing their tails and making sore spots. The "Burton" allows horses to be more quickly loaded and unloaded than any other car.

There are several kinds of slatted cattle cars that might be used for shipping horses, but they have few if any of the necessary conveniences for watering and feeding. In these cars, there are ordinarily packed from eighteen to twenty-two horses, stowed as best they may be. The vicious, kicking and biting animals get more than their rightful share of room and crowd the others into small compass. Should a horse get down in a car of this kind, he is in danger of being badly injured and rendered unserviceable.

Some of these cars have a metal feed trough, hinged along the sides, which can be removed when not in use ; but not all of them are so provided. "The Inter States Law" requires cattle to be unloaded every twenty-four hours, so that provision for feeding has not been made. Nose bags and buckets have therefore to be used, and the men crawl into the cars through a "man hole" in the root. Ordinary box cars might, when necessity requires it, be used for transporting horses, provided the cars can be properly ventilated. The car floors should also be cleated to prevent the horses slipping. There is always danger of fire if hay be fed, but this is especially the case in slatted cars. It has been reported that two such cars loaded with mules were burned up in this way, during the mobilization in the spring of 1898. "The Arms Car" is somewhat dangerous on this account, as the windows at the ends open directly into the feed trough and the draught is apt to carry in cinders from the locomotive.

"The Burton" is, on the whole, in the estimation of the writer, by far the best car for horses, and quite as safe as any ordinary box car.

On journeys of more than thirty-six hours duration it is desirable to unload the horses, exercise them for an hour or more and hand rub their legs. The horses should then be allowed to roll, after which it is well to groom them. This greatly refreshes the animals and insures their arriving at the journeys end in good condition.

In conclusion we will quote what Captain John Bigelow, U. S. Cavalry, has to say on this subject of horse transportation. "The horses were put into cars with their heads where their tails should have been, but the railroad people did not care, so long as the cars were loaded and moved *****. About two hours and a half were spent in watering and feeding the horses. The forage was taken out of the baggage car, hoisted to the top of it, distributed along the top to the several stock cars and fed to the animals through openings, which we had some difficulty in finding and working. The water was fed by a hose from a hydrant, into troughs running along both sides of each car on the inside. The horses were first watered in these troughs through the grating forming the sides of the cars. (Grain was then fed to them in the troughs.) As some horses faced one way and some the other they had dropped more or less dung into the troughs on each side of the cars. The troughs were designed to be emptied by turning them over but the mechanism by which this was to be done would not work; and as a consequence, the horses had to be watered with dung and water which most of them sniffed at and would not drink." So much for the stock or cattle car as a means of transportation for horses.

Transportation by Sea.

The Light Artillery Brigade of the 5th Army Corps embarked at Port Tampa, Florida, for Santiago, Cuba, on the 3rd of July, 1898. The steamer *Comanche* carried the Headquarters of the brigade and the larger part of the command, while two "tramp" steamers, the *Specialist* and *Unionist,* were used for the battery horses. Four batteries of the First and Second Artillery had preceded the brigade proper, having been selected by lot for the original Shafter expedition. Arriving at Siboney, July 9th, the *Comanche* after receiving orders joined the horse transport steamers; and on the morning of July 10th, the debarkation of horses commenced at Baquiri some 20 miles from Santiago. It was by no means an easy task to get the horses out, as each one in turn had to be hoisted over the side on to the deck of a lighter, which was afterwards taken to a small pier. The landing was effected however without loss of men or horses.

In the transportation of horses by sea those of the artillery did not suffer to the same extent as the stock of the first expedition. The artillery horses were generally placed between decks, and were supplied with good air through the ports, and when landed were not dropped into the water with risks incident to swimming ashore, but were lifted on the deck of a lighter and transported in this way to a pier.

The temperature of this tropical climate at the time of our arrival compared most favorably with that of Port Tampa. The surrounding foliage with its setting of hills and valleys and the everlasting green of the chaparral served many of us as a reminder of the Santa Clara Valley, California. The water in one anchorage was so clear that the bottom was perfectly seen at a depth of twenty feet, and men of the batteries were glad to take a swim before starting for the front.

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[*] Captain Parkhurst, in referring to the march of his battery over this same route with the advance of the 5th Army Corps at Santiago, says:

"The march from (B or D) Daiquiri to Seville was anything but a picnic. The batteries were loaded down with their full complement of ammunition, three days rations, and with all the hay and grain that could be loaded upon the ammunition chests. The roads were simply vile; narrow, uneven, with sharp turns and pitches, full of rocks and chuck holes and, last but not least, full of men; it was now that the bad effect of green horses and green drivers began to be felt, to say nothing of the leg weary condition of all of the stock from its confinement upon ship-board, to overcome which there had not as yet been sufficient time of rest. * * * * *

"How well or how ill this march might have been performed with thoroughly trained horses and drivers will never be known. It is well known, however, that in many cases the green horses and green men were worse than useless, they were actually an incumbrance. One pair of awkward green horses in a team of six would often balk and render useless all

Under "rush orders" the first to get away were Battery "F" of the 5th (Reilly's) and Battery "F" of the 4th (Taylor's).

March from Daiquiri.[*]

The condition of the roads necessitated the abandonment of caisons and battery wagons with the greater part of the ammunition, but by so doing the gun teams could be increased from six horses to eight.

Our first night's bivouac was one long to be remembered, following as it did, the daily tropical rains before referred to, but in spite of the condition of the roads (so called), we resumed the march at early dawn on the following day. This was July 14th, the day of the informal surrender, and at 10 a. m. we were placed in the line of trenches, by the Adjutant of the Brigade with a warning. "Haggling over the terms of surrender is anticipated" he said, "and it may be necessary to give the enemy a little persuasion, in the way of a bombardment."

Had this bombardment been ordered, we should have been embarrassed by two considerations; one, that we had reached the front with but one limber chest of ammunition for each gun; the other, that the Red Cross flag was flying from nearly all buildings within sight of the gun emplacements.

It is doubtful, however, if this flag could have been respected.

The informal surrender followed; and on July 17th, the date of the formal surrender, the two batteries of the reinforcing column which had reached the front, were brigaded with the batteries of the First and Second Artillery, which had taken part in the battles of the campaign.

The batteries of the Third Artillery, with one of the Fourth and one of the Fifth, which had accompanied us as far as Daiquiri,

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the energy and effort of the other trained four; often the green horses had to be taken out and their places supplied by some of the old horses from other teams before the carriage or caisson could be budged from the chuck hole, or be pulled up a steep incline. This caused not only delay, but also made double work for many of the old horses; all of these set-backs were well understood and taken as a matter of course by all of the artillery, but were apparently little understood or appreciated by anyone else. * * * * * *

"The stock was suffering from the heat and oppression of an unusual atmosphere even more than the men. They were watered whenever and wherever practicable; at times eight and even ten horses had to be coupled up to get the carriages through; hence the march, though short in actual distance travelled, was very hard upon both horses and men.

"Unlike the universally accepted idea, as believed by those *not* in the light artillery, and as pictured forth in the many beautiful but fictitious representations of light artillery, the men (cannoneers) marched on foot, each carrying his little (?) blanket-roll and rations the same as any 'dough boy.' There was no thought of such a thing as these cannoneers sitting up, upon the limber chests with arms folded and taking it easy, while the rest of the troops plodded through the mud. Each and every cannoneer had to march as I have said, and, besides this, they had to tug and strain, use pick and shovel or other tools, fixing 'chuck holes' in the road, and helping stalled teams, etc., working, as well as marching, to get everything through as soon as possible.

had not (at the time) been infected with yellow fever, and returned under orders to the point of embarkation for the Porto Rico expedition.

The experiences and vicissitudes of the army encamped in and around Santiago, after the surrender of the Spanish forces, and until its return to Camp Wikoff, Long Island, are well known.

The campaign has made clear the value of practice marches for light artillery when the organizations are on a peace footing. To pass, however, from this condition to a war footing when engaged in active operations in the field leaves scant opportunity for the instruction of recruits and the training of new horses; and every artillerist now knows, better even than before, how urgent is the necessity for maintaining our light batteries, permanently on a war footing.

E. M. BLAKE,
1st Lieut. 4th U. S. Artillery.

West Point, N. Y.,
Oct. 20, 1899.

IMPRESSIONS OF THE BOMBARDMENT OF PUERTO RICO.*

Reprinted from *Memorial de Artilleria.*

The bombardment of San Juan, being the only deed of arms of its nature during our fatal contest with the United States, the prolonged silence kept about it in this publication by us of the Artillery who took part in the defence of that Fortress might be interpreted as indifference to the service; indifference which would be all the more reprehensible since of late personal enthusiasm has led to the disregard of superior orders and there have been published in this review studies as interesting as those which we have recently read referring to the Sea Coast Artillery.

This silence I have observed (and I believe it has been the same with my companions) through motives of prudence and professional delicacy; of prudence, because the mention of the deficiencies which prevented us from obtaining a triumph more palpable and complete, saddles an implied censure upon those who might in opportune time have supplied these deficiencies; of professional delicacy, because it is sad that in the most recent, or rather in the only combat between the fortress and a modern squadron, from the lack of good observation and of a system of range-finding, from the bad grouping of the guns and from the want of some auxiliary services, the technical deductions which we have been able to make should be so scanty.

But in the absence of a methodical study, I publish this article which, for the reasons which I have set forth, I hasten to term merely impressions. I am impelled to do this by the duty which we all have of contributing something to our common sum of work—no matter how slight may be the effort brought forward. Moreover, I think that an honest observation made during the actual combat affords more light than many others which, although advanced by observers of greater authority, are based on simulated combats or on purely theoretical foundation.

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* The Artillery Corps, as is its duty, is perfectly acquainted with the defensive conditions of all of our Fortresses and Coasts, but it is fitting that the general public should know by what to abide with regard to the calamitous past, so that, impelled by misconceptions and idle rumors, it may not throw blame on those who do not deserve it. (Ed. of *Memorial.*)

PRELIMINARY MATTERS.

Through the initiative of General Despujols there was drawn up in San Juan in 1882 a plan for armament in accordance with the advance of the times; and I remember that among various others there appeared two 30 cm. (12″) Krupp guns, 35 calibers long. The general succeeded in securing for this purpose an allotment of 80,000 pesos annually but it was continued only two years since through parliamentary reasons of economy * and in order to make allotments to other services, the above mentioned apportionment was cut off. It is also true that in order to facilitate the discontinuance of this appropriation there was then a Governor General who said that with small arms he was more than able to defend the Island. May God keep this good man in glory. His name is omitted although we remember it perfectly.

With these 160,000 pesos there were bought one of the 30 cm. Krupp guns, an 80 ton crane, a strong car for the same weight, and some other articles of less importance, and the funds being exhausted, the purchases came to an end.

As soon as modern artillery was thought of, difficulties arose about its location. The pre-eminent point for the defence of the Fortress with respect to attacks from the sea, was, as recognized by all military men who have visited the spot, and as the recent attack has confirmed, that point occupied by the Morro Castle.

This fortification, strongly traced in accordance with the principles of an approved system, but necessarily following the course of the rocks upon which it rested, had, or rather has, very narrow terrepleins and very small bastions. In short, the trace is one which, whilst very well planned and quite sufficient for the period in which it was laid out, has not within it any site upon which it would be possible to mount, even under mediocre conditions, modern artillery of large calibre. Notwithstanding this, it was indispensable that the greater part of our fire be located there, for besides defending the entrance to the harbor, it commanded the fortress which lay longitudinally in front and below. In the face of this necessity the pieces were placed as best they could be, that is to say, in very bad conditions.

The evident solution was to remodel or demolish the castle, but to the Engineer or General who would have advanced this plan asking several millions to carry it out, not the slightest

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* It is to be remarked that some years the budget for the island was paid with a surplus left over.

attention would have been paid.† This impossibility of placing modern artillery in a narrow and antiquated enceinte, crowded with buildings, compelled the Engineers to locate their new batteries in situations where they were less efficacious in resisting attacks which were logically to be expected. I dwell upon this digression because, in emphasizing defects with all sincerity, I find no one personally responsible. Moreover, I take pleasure in acknowledging that the military engineers, individually and collectively, were filled with intelligence and zeal, not only to understand and correct such obvious defects, but to have made of it a model fortress. On the part of the artillerists, I affirm that there was no want of prudent protests, insistent requests for what was lacking and timely remonstrances. I will also mention authorities filled with enthusiasm to put the fortress in a state of defence, and nevertheless, the dreaded moment came and found it in a very precarious condition as regards materiel and auxiliary services.

Whose fault was it then? Was it the fault of the system by virtue of which a ministry of the colonies (*Ministerio de Ultramar*) and a committee of deputies varied according to caprice the budget of countries with whose conditions they were not acquainted? Is it our customary lack of foresight? Is it perhaps the fault of that corruption which, in the presence of the greed and fees of politics, declares remote and makes light of the damages of the country? This speculation, for a soldier who writes a few modest annotations, is forbidden ground, and I return to my story.

For lack of a wharf in which to erect the 80 ton crane, this was found by the Americans sixteen or eighteen years after its arrival, stored away in perfect condition. It had been put up and taken down, for the pleasure of seeing it and remained without being permanently mounted, offering one of the most curious instances of Spanish procedure. The military engineers submitted two or three plans for military wharves, all good, but, in order not to incur the expenditure which their execution necessarily involved, they were all rejected. The Committee on Docks declared that the wharves could not support the weight of the crane and they offered solutions which they never carried out. Finally, we artillerists concluded to unload the cannon without using a crane, but we had to ask that the transporting vessel should be detained at our pleasure whilst the cannon were drawn out from the ship. The Transatlantic line, which seems to be the only one that could furnish transportation, made suggestions from time to time, and in such discussions there passed years and years.

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† It has been necessary for the country to see dimly the liquidation of our disasters for it to feel that the victories or defeats of a nation are translated into thousands of milions. A thing which it does not even wish to understand is that a few millions employed opportunely are indispensable to obtain the former or to lessen the latter. With modern guns in Santiago, Manila and Puerto Rico, the American squadron would have suffered grave losses, and then there might have been concluded a peace less leonine than the treaty of Paris. I cherish the sad conviction that we will still continue expecting everything from general "indifference" and forgetting the axiom that omelettes are not made without eggs.

In 1896, the then Governor General, Don Sabas Marón, put himself on the Committee of Works and made it begin the work of a base on which to erect the crane, but he had hardly time to commence the foundations. Worn out in Madrid, (and naturally so), by such a long process, the authorities decided to keep the 30 cm. gun, and to give us in exchange its value, and more, in 15 cm. (6″) Ordoñez pieces and 24 cm. howitzers of the same system, and to send us, when there would be means of transporting and unloading, 24 cm. (10″) guns. These last we never received.

The 15 cm. guns and the howitzers arrived during the year 1894, and as the construction of the new batteries required some time, General Dabán ordered that the 12th Battalion aided by the Park Detachment (*el Parque*) should mount some of them provisionally. With 1000 pesos which had been allotted for practical instruction (*Escuelas prácticas*), and by the labor of the artillerymen of the 12th Battalion, the guns and howitzers were mounted, the batteries receiving the names of San Antonio, San Fernando and El Carmen.

The work thus carried out had no especial merit but I mention this detail as an indication that we artillerists, through the foresight of the General who ordered its execution, and through the desire to have guns with which to reply to the enemy, did even more than was within our province, moreover, good and bad, these batteries delivered much fire on the 12th of May, or rather, they were the ones which discharged the greatest number of shots.

Various authorities succeeded one another and in 1896 the command of the Island was assumed by General Marón who, as much because of his predelictions for the artillery as because of his understanding the imminence of the danger, took up with so much zeal the question of San Juan's being made a strong fortress that, if his command had lasted longer and had the war been delayed, the condition of the fortress would have been very different.

In this time, the new batteries of the northern part were completed and armed; he began, as we stated above, the pivot for erection of the legendary crane; he repeated the requisition for rapid-fire artillery * and for that necessary to defend the land front of the fortress; he approved the scheme for the range finding service, which service, on account of the difficulties and pecuniary delays which it experienced after he ceased to command, was not ready, as was also the case with the search light which arrived days after the bombardment.

Towards the end of the year 1897 there remained no more that could be done except to think of making the best of things as they were. From this time the artillery force was devoted exclusively to the duties of its arm; permanent cannoneers were assigned by pieces and by batteries, the service magazines were fitted up in the best manner possible; the mounting of the pieces was completed; the projectiles that needed it were calibrated; in short, we worked continuously to be able at the first signal to open fire under the best conditions.

BATTERIES AND THEIR MATERIEL ON THE 12TH OF MAY.

Morro. On the cavalier or flat roof (*azotca*) three 15 E pieces on the curtain of the North West front, separated by traverses and with small service magazines, besides, the parapet which was very low, was raised in front of the pieces. The crest of this was partly carried away and the traverses somewhat destroyed, proving thus how intelligently they had been located since they prevented the battery from being totally dismounted. In each of the bastions at the extremities of this curtain a 24 Ordoñez howitzer, protected by blocks of concrete (*hormigón*); one was below the light house light and the other below the semaphore. In time it was shown that this constituted an excellent point of aim (*taget-referencia*) for the enemy and a danger for the pieces. We were told that when the time came it would be shot away and so it turned out, because after a few minutes of bombardment the top part of the light house tower fell down upon the howitzer—fortunately without interrupting its fire. There were no ammunition hoists or tracks to move the 24 cm. projectiles, consequently they were dragged up on sleds from the lower floor, exposed the greater part of the way.

El Carmen Battery. Two 15 cm. (6 inch) C. H. E. The battery was a small court which had for a flank a high wall and behind and very near a steep slope. There were neither service magazines nor traverses and in a hollow in the parapet, which was the termination of one of those old stairways, was placed a heap of charges.

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* Cabled for several months before the declaration of war, the rapid fire battery was finished some months after the signing of the treaty of peace. This shows plainly the error of the belief held by many people in Spain, namely, that artillery is kept for sale on the shelves in stores just like target pistols.

Annexes to the Morro. San Antonio and San Fernando. The first 4 15 cm. (6 inch) C. H. E. and the second 4 21 cm. (8½ inch) O. H. muzzle loaders. There being no service magazines, the first kept its ammunition in a room which served as a sleeping room for the sentries; the second of earth and sod kept its ammunition in one of the casemates of the Morro (400 metres distant) and fitted up some recesses to hold five rounds for each piece.

Santa Elena. Four 15 cm. (6 inch) C. H. S. without traverses or service magazines and with slight protection. was in very bad condition to withstand fire.

San Augustin. Two 15 cm. (6 inch) C. H. E. Had a good service magazine.

Castle of San Cristóbal. In the battery called *Los Caballeros*, 3 15 cm. (6 inch) C. H. E. simply mounted on the parapet and this was so low that it did not cover the gunners above the knees; in the place of arms two 24 cm. (9½ inch) O. H. and in the "Macho" one 24 cm. O. H. which at that height and alone looked like an astronomical telescope. Ammunition hoists and tracks were lacking and the ammunition had to be carried up ramps with great labor.

As in the Morro, so in San Cristóbal, the casemates were taken to convert them into cartridge work shops and service magazines for the batteries. Some in Cristóbal were completely dark and those of the Morro had embrasures which opened upon a scarp in which more than 200 hits were counted.

We must admit that the Americans were not fortunate when the castle did not blow up.

Santa Teresa, La Princesa and El Escambrón. The first with two 15 cm. (6 inch) C. H. E., the second with two 15 cm. (6 inch) C. H. E. and two 24 O, and the third with three 24 cm. (10 inch) O. H. were modern batteries, ample and well traced. On account of their situation they were not the most battered nor could they contribute much to the attack on the squadron. The Escambrón either did not fire at all or only fired a few rounds; and it is sufficient to see a sketch of the fortress to understand, as the practice showed, what a mistake the location of the howitzers in this site was.

There were besides two 15 cm. (6 inch) C. H. E. in *San Carlos* which bore upon the inner harbor and which, for this reason, did not fire.

To summarize them, in the north west section, especially battered by the squadron, there were mounted 7 15 cm. C. H. E., 2, 24 cm. howitzers, 4 of 21, muzzle loaders, and four 15 cm. C. H. S. The fire of the other batteries contributed what they could to injure the squadron, but the the latter, as soon as it moved to the west, escaped this fire.

Auxiliary Services. There being no range finding system, an order was received a week before the bombardment to improvise a means of estimating distances. Any apparatus that might be found in the government offices was placed at our disposition since in the local business houses there was nothing suited to the purpose. It was determined to employ vertical circle instruments which being placed on the summit of elevated points would, by calculating and copying out the corresponding tables, give the horizontal distance in angular functions (Depression Range Finders. W. R.) Even though the instruments employed were the two largest circled theodolites which we found, I leave to the imagination of the reader the rapidity and accuracy of this method.

An overhead line was put up, and San Cristóbal, Morro, Princesa, and Escambrón were connected by telephone. Artillerymen were detailed who instructed themselves in the use of these instruments as best they could, and by the 11th, although suffering from the defects inherent in the conditions of rapidity and the few resources at our disposal, everything was completed.

Personnel of Troops and Artillerymen. There were not enough artillerymen—this service, so evaded in time of peace, hardly sufficed to man the batteries, to care for the magazines, telephones, etc. ; and as in the greater part of the batteries the ammunition had to be brought up by hand from great distances, the problem had to be solved as best it could. The authorities of the fortress resolved to appeal to the patriotic sentiment of the populace, and in a few days there was organized a so-called "artillery auxiliary," of all classes of colors, since there were whites, negroes (blacks) and mulattoes. The same heterogeneity existed in their qualities and professions, since by the side of government employes and clerks of finished education lined up cart drivers, stevedores, etc.*

The best were selected, they were assigned to positions to move the ammunition from the places in which it was stored to the batteries and they performed good service ; some shed their blood, and others (although the minority), remained by our side to the last hour ; the immense majority, after the attack of the 12th and as the news grew worse, evaporated, as happens with all popular forces, capable only of brief bursts of enthusiasm.

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* The having, before experiencing any casualties, to call upon civilians to save seacoast artillery in the year 1898, is more eloquent than anything else to demonstrate how the service progresses in Spain.

The enlisted men and some of the trustworthy volunteers (*eventuales*) were assigned to the batteries, and given the necessary implements, and they rendered excellent service. The trained ones and the auxiliaries performed their duties perfectly during those extraordinary labors on the day of combat.

The chiefs and officers also received fixed posts, and those of the Park Detachment were assigned posts in the batteries. For several months the gunners and artificers had not been changed, nor had the companies, which had fixed zones, and it was arranged so that they were quartered in the immediate vicinity of the pieces which they had to serve.

It is so agreeable to award praise that I do not wish to go farther without bestowing a well deserved eulogy on the personnel of the extinct 12th Battalion. This I may do freely because the part that I played can have little or no effect on its brilliant reputation.

Working at moving and mounting pieces and at various maneuvres at all hours of the night and day, always at the call and within sight of their officers, resisting without interruption the tropical soon and night dews of that climate, they were in general trained artillerymen, hard working men, acclimated and filled with the best spirit. Far from injuring their health by such heavy labor, with the extra pay which the Park paid liberally they supplied themselves with very good messes and rations of wine, and sustained themselves perfectly. As their good military condition and physical state were due to the management and good administration of which they were the object, this praise redounds to the individual commanders and officers of the the disbanded battalions.

Neither should I conclude this account of the antecedent affairs without stating positively that in the days which preceded and followed the attack on the fortress the Governor General Macias as well as General Ortega, the second in command, afforded us every resource and help which they found in their power. The activity of this last general, devoted especially to the fortress, was prodigious, and both knew him by their example and talent for command to keep up to a high point the spirits of the garrison.

I have not mentioned before the artillery commanders of the fortress, our Colonel—Don José Sánchez Castilla, because it is needless to say that whatever was done by the artillery was ordered and inspired by him. On this, as on all occasions, the unity of purpose which exists among us was evident (was made patent).

THE ATTACK OF MAY 12TH 1898.

Thanks to good coast pilots furnished by people of the locality and taking advantage of a very dark night the hostile squadron, composed of eleven vessels, surrounded the fortress, opening fire at the earliest dawn. During the first moments the fire was very heavy, as with all the heavy artillery previously loaded and firing at short range, and even the auxiliary cruisers joining in with their pieces of small calibre and rapid fire, some portions of the enceinte like that called "Campo del Morro," were thoroughly swept by the projectiles. Not the slightest disorder was produced in the garrison who all had had their posts designated previously, and in a few minutes the first, and before twelve minutes, the last of the batteries replied to the fire. From that moment, with the exception of the armored Iowa and Indiana and the monitors, the other vessels remained at a great distance and the attack was concentrated against the Morro Castle and adjoining batteries.

The vessels moved continually with great speed and in our opinion with great concert, without ever becoming massed or having among them any misunderstanding of signals or analogous thing.

Their attack which lasted barely three hours consisted of three successive advances. The armored vessels and monitors advanced in the first line, discharged the greater part of their artillery, and without diminishing their speed turned away and retired. The weaker vessels always kept at distances greater than 5000 meters. The vessels which came nearest were the two armored men of war which in the last advance came within 1500 meters of the salient of the Morro at which they fired almost simultaneously the guns of their turrets and *this time* withdrew permanently.

They fired frantically and they shot very poorly. It is sufficient to say that in three hours there were expended 2000 rounds of heavy and medium calibre *, and three or four times as many from the Nordenfeldt and Hotchkiss small calibres, and with all this metal expended they disabled only one 24 cm. (10 inch) howitzer; and kept down the fire of only the Carmen Battery, where an officer and several gunners were wounded. It was not noticed that they either rectified their aim or stopped a moment to make sure of its effect, only they fired a great deal and very rapidly.

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* According to the official data of the American Squadron the number of projectiles of these calibres was approximately 2000.

Fortunately, they made no use of shrapnel, for, if those projectiles which fell on the terrepleins had been of this class the cannoneers would have been disabled in large numbers, and we have already said there were none to take their places. There were picked up a great number of projectiles with fuzes and without explosive charge, and, among other fragments, one which proved that the piece which fired it, a 13-inch gun according to indications, must have been disabled since the body of the projectile had entered the piece in such away that the grooves of the rifling had deeply scored the steel of the projectile. The greater part of the projectiles were of the best construction, of good material, and of the lengths employed in modern projectiles—others, in a much smaller number, were old-fashioned, of little length and came evidently from the monitors. Of the 12 and 13 inch there were collected some eight unexpected projectiles, one more than 10 kilometers from the fortress.

We could not ascertain the injuries to the squadron. In the official cablegraphic report of Admiral Sampson he says that his vessels suffered injuries. There were picked up thrown overboard a box of implements and another of medicines marked "Amphytrite" which was the name of one of the monitors. Upon the withdrawal of the squadron we saw on the horizon that one of its large vessels was boarded by two others as if convoying it, and later, that night telegrams were received from the towns of the north coast confirming that one of the larger vessels was withdrawning under tow. The papers and news correspondents of Cape Haytien, all hostile to Spain, reported the burial with military honors on the 13th of several sailors and an officer. We do not know the truth of this but none of these details affects the decision of the combat.*

On our side the fire was maintained with the greatest tranquility and order, as is proven by the fact that the number of shots fired by the fortress in the three hours was 441. The guns were not fired except when the smoke and dust being dissipated, the squadron was seen, and the distance was always estimated beforehand and possible corrections made. Upon the retirement of the squadron our fire was more regular and sustained than at the beginning of the combat.

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* The "Mundo Naval" (Naval World) of August 15 gives extracts from American publications referring to the war; according to them one vessel alone, the Iowa, received eight 15 cm. (6 inch) projectiles in its hull, and one on deck which destroyed a boat and started five fires of minor importance.

The destructions to the materiel were—one 24 cm. howitzer disabled by a projectile which carried away the breech block killing one cannoneer and wounding others, and in the Carmen Battery a davit twisted, and at the same time the officer and four cannoneers of the piece disabled. Immediately behind the American Squadron, the French Cruiser "Regnault de Saint-Augely" came out from the harbor, and her crew, seeing our artillerymen on the top of the parapets cheering our flag, and upon seeing how they had sustained the fire in spite of the violence and combination of the attack in turn cheered the garrison and especially the artillerymen.

We cannot conjecture the object of the hostile squadron nor justify its conduct as Naval Strategy (*Marina Militar*). Was its object to destroy the urban property of the inhabitants of a city which they, the Americans, hoped to conquer? This is not likely. Was it to take possession of the fortress by forcing the entrance to the harbor? They did not do it. Was it to silence the fire of the fortress? Then after three hours of combat they disabled only one cannon. They must doubtless have had a poor opinion of us when they expected that the fortress was going to surrender after nothing but a disorderly and rapid fire.

They have said that their attack was based on the hypothesis that Cervera's squadron was in the harbor. Aside from the fact that they had spies and sympathizers more than enough to know the truth, is a fire kept up for three hours and is half the supply of ammunition consumed to ascertain this? If on the conclusion of the bombardment, the Spanish Squadron had appeared, even with the material superiority of the American fleet, this latter would have found itself in poor condition for a combat. Their Admiral himself said that he had to cease firing because his guns were too hot and his men needed rest.

Another thing which appears in one of Sampson's communications is that he, according to his statement, had received erroneous information from the War Department, since, he adds, "the fortifications, although old, are solid and not weak as they have said." This explains, more than anything else, the conduct of the squadron and its manner of firing, which was to advance the armored vessels several times and to fire the turret guns at short range as if to demolish the Castle. But this error (of the War Department) does not absolve them from their own. However weak permanent fortifications may be, can they be demolished otherwise than by a methodical and regular fire?

The Admiral said that he left the fortress destroyed; and we have already seen that with the exception of one howitzer, the whole fortress said farewell to him with cannon shots. Whatever may have been his plan, it failed competely, and if we compare the forces which contested the victory, the judgment is more severe for the Americans. (See one of the final notes). On one hand, armored vessels of the first class and protected cruisers as perfect as the Iowa and the New York with steel guns of 32 centimeters (13 inch) and with very numerous and perfect rapid fire artillery; on our part as means of offence 15 cm. (6 inch) iron guns, very few 24 cm. howitzers, and not a single rapid fire piece—and as means of defense, very rudimentary barbette batteries like those of the Morro. The others, El Carmen San Fernando, etc., were simply guns placed behind the flat top of a wall.

Are we to deduce from this that artillery mounted on land is invulnerable from vessels? Not by any means. As will be seen from the final note, all of our terrepleins received projectiles, the parapets had their crests carried away and their traverses partly destroyed. But what is evident is that, firing almost always from a distance and blindly, no more harm is done than what results from accident. If our artillery was not dismounted, it was the fault of the Americans who never stopped a moment to make sure of their fire, and who would risk nothing to come out of their undertaking successful.*

The powerful squadron withdrew after three hours of fire, from before a poorly armed fortress without succeeding for a single moment in diminishing the fire of the artillery of the fortress, from which it received injuries according to its own confession. It did well to withdrawn for to continue to attack it would have completely emptied its magazines, and according to the doctrine of probabilities it would have dismounted, altogether, one piece more.

The more powerful failed through the disorder and blindness of its attack; the weaker conquered by its discipline and its tranquil conduct. They well deserved then, those artillerymen, the greater part of whom received that day a baptism of fire, the praises which were heaped upon them.

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* Had a single vessel repeated the maneuvre of the Condor during the bombardment of Alexandria by the English fleet, it would have obliged us to abandon the low batteries. if in that period (Alexandria Bombardment) the maneuvre was successful, to-day with revolving cannons and perfect machine guns how would it have been possible to resist?

OBSERVATIONS.

I do not wish to conclude without giving my personal observations upon the combat.

1st. Our powder produces too much smoke. On several occasions fire had to be suspended because it was impossible to see either the vessels or the sea. It is however true that it was a period of absolute calm, but fleets, controlling the time of opening combats will always select such times to avoid the rolling of the vessels. Moreover, the disadvantage of excessive smoke (the powder of the Americans produced very little) is not mutual for the vessels, moving continually, draw away from that which they produce and it does not impede their vision, whilst that of the batteries blinds the defenders and indicates perfectly the position of the batteries themselves.

2d. All stone work must be avoided in batteries. Only on the interior slopes or on the lower part of traverses may it be permitted, and always in these last covered over with earth and grass. Neither on the rear (*retaguardia*) nor on the flanks should there be an inch of cement or stone work exposed.

3d. Barbette batteries need at least 14 to 16 meters (45 to 50 feet) of elevation. Low barbette batteries, unless in very especial positions, can not be fought if they are attacked with resolution by vessels which use the fire from their tops.

4th. The moments in which vessels moving with a speed of 12 or 14 miles may be fired on are so short that to do so effectively it is necessary that enough pieces be grouped which should be of very rapid fire, and moreover, that each battery should have its own means of estimating distances, since the aspect and situation of these vessels change with such rapidity that the data (*indicacions*) received from a central station can not be used except with an uncertainty, hesitation and loss of time which will deprive it of its value.

5th. As a defense against bold attacks by vessels and also as a range finder, all the batteries should have some rapid fire pieces of small calibre. They occupy but little room, one man is sufficient to serve each, and for defense and obtaining range (*indicaciones*) we consider them indispensable.

6th. Many officers are absolutely necessary in sea coast batteries. Aside from the technical requirements (those officers required as per drill regulations). They are needed to preserve by their example the coolness and discipline of the men who have to stand firm under a fire from which they can shelter themselves by running only a few meters.

7th. Our gun of 15 E. is, for its small caliber, very slow to lay. The 24 cm. howitzers very hard to load; if the projectile is not presented perfectly in the direction of the axis it is very troublesome to extract it and the obturator ring? (auillo) usually comes to the rear. This is bent easily and it has to be changed. In the combat which I describe the rings of the two howitzers had to be replaced, and as during fire substitutes must sometimes be put in place of the artillerymen, one could not depend at all upon skill acquired by dint of practice. We also believe an adjusting tool for each two or three pieces to be indispensable.

8th. In the armament of a seacoast fortress there should not be wanting some pieces capable of piercing heavy armor, but especially there should be an abundance of medium calibres (in the neighborhood of 20 cm. 3 inch) of very rapid loading and laying. Pieces for curved fire have also their place so indicated that their number should depend upon the positions which the site affords them. For this reason, they should be grouped in sufficient number on an elevated situation and always bearing on spots where the fleet will be compelled to lie, never on the open sea.

And in conclusion, I repeat once more that in the sea coast artillery there is no place for makeshifts, for things improvised on the spur of the moment. To obtain tangible results everything, to the smallest detail, must be thoroughly prepared in advance, and as I fear that perhaps very soon our companions may again see themselves in an analogous situation to the one from which we artillerymen extricated them on the 12th of May, 1898, I conclude by wishing that if it so happens, Providence may grant them an equal fortune to that with which He favored us.

NOTES.

1st. Official report of the injuries to the Morro Castle after the combat of May 12, 1898. Data furnished by our friend Señor Ravena, Commandant of Engineers.

Carmen Battery. The casemate destroyed and a volume of 5 cubic meters of the old wall In the stairway of the (*macho*) which formed the shoulder (*espaldon*) of the battery a projectile has knocked down half a cubic meter and another has caused, near the foundation, a similar damage.

The Cavalier (*macho*). Between the 15 cm. Ordóñez gun and the central gun 2¼ cubic meters of the parapet has been knocked down; between the central piece and the east ⅕ of a cubic meter.

In the service magazine of the east piece a shell broke the window (*ventana*). The earth covering was pierced by a projectile which remained embedded in the concrete.

In the bomb proof (*cebertizo*—covered porch or shed) situated at the west, 16 cubic meters of the roof, and 5 cubic meters of the northeast wall have been knocked down.

In the central embrasure of the gun battery ½ cubic meter of the crest of the parapet destroyed.

One cubic meter of masonry destroyed where formerly was placed the steps (*paso*)) of the semaphore and the crest of one of the embrasures.

In the concrete parapet of the northern howitzer are two impacts, one of them within ½ meter of the plane of fire has made a crack of a depth equal to a third of the length of the parapet, and the other impact has produced a similar and equal crack.

In the scrap of this cavalier (*macho*) there are some 46 impacts of heavy or medium caliber.

The ramp leading down to the Santa Bárbara Battery—a 15 cm. (6-inch) projectile pierced the scarp and entered a casemate (*calabozo*) perforating a masonry wall of approximately 3 meters thickness.

On the other ramp a projectile knocked down three cubic meters of concrete.

Santa Bárbara Battery. A projectile knocked down in the 3rd embrasure 1½ cubic meters of merlon and a part of the scarp. Another knocked down ¼ cubic meter in the next embrasure. In the lookout (*garita*—sentry box) ¼ cubic meter knocked down, and in the lower part of the corresponding angle a projectile produced a downfall of 2½ cubic meters. There are other damages of about ¼ cubic meter in an embrasure in front of the service magazines of this battery.

A projectile of heavy caliber which struck the north angle produced a downfall of 16 cubic meters. In the west angle the lookout has fallen from the effect of a projectile which striking the scarp destroyed 15 cubic meters of masonry. Another equal volume obstructed the descending stairway of the Carmen Battery. In the *escucha* of this battery there is a downfall of 8 cubic meters and in all the scarp a great number of impacts of all calibers. The impacts of projectiles of large and medium caliber in the scarp walls are some 200 in addition to those mentioned.

In all the other batteries, including the modern ones, there were injuries, and several military buildings were almost ruined, two fires were also started in the town.

2nd. We give the list of the vessels of the squadron as we were able to determine them from the fortress. There may be errors in the names of some, but we would have to substitute for them names of others of the same type and consequently of equal armament.

NUMERICAL COMPARISON OF THE ARTILLERY OF THE SQUADRON AND OF THE FORTRESS.

Vessels.	Guns.
Indiana,	four 13″, eight 8″, four 6″, and thirty R. F. and machine.
Iowa,	four 12″, eight 8″, six 4″, " " " " "
New York,	six 8″, twelve 4″, sixteen " " . "
Amphytrite	four 10″, two 4″, six " " "
Terror,	four 10″, eight rapid fire.
Detroit,	nine 5″, ten " "
Montgomery,	nine 5″, ten " "
Castine,	eight 4″, eight " "
Petrel,	four 6″, seven " "
Womphatuck,	eight 4″, ten " "
Another Gunboat	eight 4″, ten " "

The sector especially fired on included 9 C.H.E. 15 cm. (6″); 3 C.H.S. 15 cm. (6″); 2 O.H. 24 cm. (9½″), and 4 O.H. 21 cb.

The fleet had steel guns over 15 cm. (6″) 38	The fort 6 howitzers of iron, 21 to 24 cm.
The fleet had steel guns of 15 cm. (6″), 12 cm. (5″), 10 cm. (4″).. 70	The fortress 12.
The fleet had steel rapid fire and machine guns 145	The fortress none.

L. ALVARADO.

[Translated by First Lieutenant Wirt Robinson, 4th Artillery.]

A SKETCH OF THE SIEGE ARTILLERY TRAIN, AT CAMP RODGERS, TAMPA, FLORIDA, DURING THE SUMMER OF 1898.

It is not my intention to enter into a discussion of the general subject of siege trains and their organization, but simply to give something of the development of what was finally a powerful collection of Artillery and to outline some of the difficulties as to organization and equipment which were met and successfully solved.

NECESSITY OF A SIEGE TRAIN.

In the usual division of Artillery into Field, Siege, and Seacoast, we had, previous to the Spanish-American War, developed the first and third branches almost entirely, and the siege service was almost, if not quite neglected. This was but natural, for since the close of the Civil War, we, as a nation, had no use for siege Artillery and there was no prospect of any necessity for its use.

In the transition to modern guns, a system of siege pieces was designed, consisting of siege guns, howitzers, and mortars, and a number of them were constructed and stored at arsenals. To these may be added the 3.6 mortar and 3.6 heavy field piece, for both were found in the siege train. With the exception of the last two pieces mentioned, it is safe to say, that not one artillery officer out of a dozen in the siege camp, had ever seen any of the new siege pieces before joining at Tampa. Doubtless, while everyone felt that siege pieces were proper and necessary in any well considered system of artillery, few probably anticipated their use in a campaign by the Americans and their actual use as well as the perfection of minor details which could come only from practice, was therefore neglected for the more important sea-coast work. As soon as war was declared, it was seen that Cuba would be the field of operations and that we needed an effective siege train and needed it badly. While neither the siege train nor any part of it had an actual trial, still it must be remembered that the general impression was, and doubtless with good reason, that the final and principal campaign of the war would be fought about Havana, and that the Siege Train was organizing for that.

The movements of Cervera's fleet, however, at once made Santiago the principal objective, and, as it proved the final one, and with its fall the necessity for the use of Siege Artillery passed away.

It is well known that the Siege Batteries accompanied Shafter's expedition, and that owing to the numerous difficulties of transportation, did not reach the field at all, or if so, too late to be of use. When reading of Capron's battery of 3.2 inch guns pegging away at a stone block-house for ten hours, one could not help wishing that time had permitted the putting of the siege guns in position where their real value would have been demonstrated.

It is well to remark, however, that considering the difficulties of transportation, both on sea and land, there were not lacking, experienced artillery officers who believed that the heavy field piece of 3.6 inch caliber would have proved the best for the campaign, as being mobile and at the same time powerful enough.

ORGANIZATION OF THE SIEGE TRAIN.

Many difficulties experienced in organizing and equipping the Siege Train seem to have arisen from the fact that it was not directly sanctioned either by legislation or by the orders of the President or Secretary of War, that is as far as I am aware. Special Field Orders No. 13 from Headquarters of the Army, Tampa, Florida, June 14, 1898, specified, that the Siege Trains and troops assigned to its service, would constitute a part of the Artillery Reserve of the Army and its organization, equipment. and employment, were to be under the direct control of the Chief of Artillery at the Headquarters of the Army. With respect to administration, discipline, supply, and returns of troops, reports were to be made to the Commanding Officer, U. S. forces, where it was stationed for the time being.

Its status as a military organization was not clearly defined. For instance, although nearly every battery was mounted, there was no provision by which officers could draw mounted pay, except by the certification of each set of vouchers. Other questions, such as which department should furnish the harness, etc., added to the difficulties. The siege train was a collection of batteries which grew by additions, both of recruits and of organizations until it formed a powerful engine. Under such circumstances, and owing to the fact that transportation and service was necessarily almost entirely by battery, and with four different calibers of pieces, of course anything like the homogeneity of an infantry organization could not be expected.

The camp ground was the best around Tampa, being in a grove of pines and scrub oak on high ground near Ybor City. Water was supplied in pipes from a natural spring, and little if any sickness was to be attributed to its use. Batteries began to arrive on May 20, 1898, each battery being thus fairly equipped as an infantry company of about 60 men. The batteries were gradually swelled by addition of recruits to the full standard of a heavy battery, 200 men each.

This number was found to be very unwieldy and has happily been abandoned in the new organization. Recruits arrived in camp with scarcely more in the way of equipment than a blanket apiece. Everything in the way of supplies had to be drawn from the depots in Tampa, and a good portion of the time of officers was devoted to getting their men fully equipped, getting artillery equipment, and supplies of all kinds, etc. For some four weeks or more, the battery with which I was serving had for cooking utensils only two dutch ovens and a few camp kettles. This in spite of the fact that every effort was made to supply the deficiency before leaving the North. There seemed to be no regular method of obtaining supplies. To procure the smallest allowance of equipment, it was necessary for an officer of the battery to go personally to the issuing officer and procure what he could or get his share of what had arrived the day previous.

Little regard was paid to requisitions, and the rule seemed to be "first come, first served." Thus many officers were taken from their battery duties and the result was unsatisfactory. Much of this was due to the congestion of the railways and was unavoidable probably.

In the carriages lack of interchangeability of parts caused great trouble and annoyance. The guns and carriages seemed to have been assembled separately, and expert mechanics had to be employed in the field to assemble and fit regular parts, elevating arcs, etc.; work which should have been done at an arsenal and which was here performed under great difficulties. This only emphasizes the necessity of keeping at least a portion of our siege artillery equipped and in practice all the time. No matter how perfect the gun proper or how carefully the system has been devised on paper, there are a thousand and one details which cannot well be foreseen and which can only be developed, by actual trial and practice in the hands of the troops themselves, that is the artillery. The size or strength of a buckle may prove a very important factor in a campaign.

No comprehensive or uniform system of marking boxes of ammunition was discernable, so that it was found necessary to open most of the boxes of ammunition received in order to be absolutely certain of just what they contained. Boxes from different arsenals appeared to have different systems of marking. Some of the fuzes received had left-handed threads, and some right-handed, while the pitch of the thread varied. A box of ammunition would be marked "such and such shell filled and such and such fuze." Sometimes such marking meant simply that the ammunition was adapted to that particular fuze, while in other cases it meant that the fuze was actually present in the box and packed with the shell. No regular method of supplying ammunition was observable. It came in small lots and from different sources.

Much of it was unfulfilled and had to be filled in camp in all sorts of weather, and with few instruments adapted to the work.

Owing to these difficulties, many of which were doubtless unavoidable in the hurried mobilization of troops, the proper equipment and organization of the Siege Train was greatly delayed, and they are mentioned to show the necessity of providing beforehand by actual practice. A Siege Train is a complicated engine and from lack of attention to details, which at the time and in themselves may appear almost trivial, the usefulness of the Siege Train may be seriously impaired and at the critical moment it be found, that the guns cannot be brought up or served when in position. Especially is great foresight and careful practice necessary for foreign service, where supplies and spare parts are not readily forthcoming, and where improvising is at times even out of the question.

TRANSPORTATION BY SEA.

About the time of the battle of San Juan, the entire Siege Train was ordered to Santiago. Some batteries were already on the cars, but owing to the pressure for ships, only two batteries, D of the 5th with howitzers and G of the 5th with 3.6 guns, actually got off finally landed in Porto Rico, and took part in that campaign. Orders required 15 days travel and 45 days field rations and forage for 30 days.

Unless one has figured out the weights and cubic contents of space required to transport even the six batteries and Headquarters then under orders, he can form little idea of what was required for sea transport. Having done so he can understand why the required transportation was not to be obtained. The destination of the batteries, when Santiago was surrendered, was changed to Porto Rico, but finally the Commanding General sent word no more artillery was needed, and the camp finally broke up, the batteries returning to their former sea-coast stations. Exception was made of two batteries which were equipped respectively with siege guns and howitzers for practice as siege artillery, so that now we may be said to have constantly a nucleus of a siege train and may expect to derive valuable information for the future.

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A UNITED STATES GOVERNMENT PACIFIC CABLE.

By GEORGE OWEN SQUIER, Ph. D., Captain, Signal Corps,
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Great undertakings, identified with the progress of the world, are certain to be accomplished when the time is ripe for them.

The world problem, already large upon the horizon, is not limited to Anglo-Saxon co-operation—it is Western versus Eastern civilization.

The twentieth century promises for the world developments,—political and commercial,—even more marvelous than have been made in the last half of the nineteenth century in the domain of applied science. In fact, the magnificent developments of iron, steam, and electricity which have made the last fifty years so brilliant in the history of the world, have rendered possible the present material prosperity of the countries of the West, and have furnished the equipment and experience necessary before reaching out into the undeveloped and waste portion of the earth,—an impulse which is at this moment distinct throughout the peoples of the West.

With this equipment at command what can not be accomplished in this great world movement?

The beginning of the twentieth century sees within easy accomplishment a railroad and telegraph by which the entire length of the African continent is spanned, and the early completion of the Trans-Siberian railroad, by which the doors of the East are directly opened to Europe.

Nor is it unprofitable to remember that this East, which is fast becoming the center for resistless energies and activities, comprises in resources and population a surprisingly large proportion of the whole upon the earth.

In the campaign of civilization, the United States of America will surely perform its material part. Defined or undefined, expressed or implied, the participation and influence of the United States will be none the less potent.

The movement westward has not only begun, but nothing can avail to stop it.

The spirit which originally extended the colonies to the Ohio valley, thence to the Pacific coast, is the same spirit which is now moving across the Pacific ocean. In this movement, communications in their broadest sense are of primary importance, and without them success is impossible. In a study of the map of the Western hemisphere from this point of view, two undertakings stand out in bold relief, both of them of the first magnitude and both directly vital as communications between the West and the East. They intimately relate to each other, and promise in their realization the fulfillment of the idea of Columbus—a practical western trade route to the East.

It is hardly necessary to mention that the enterprises referred to are (a) An Isthmian Canal, (b) A Pacific Cable. Their inauguration can not be long delayed. The Pacific cable is at this moment a practical necessity.

It is to some observations upon a proposed United States Government Pacific Cable that attention is invited.

It is interesting to note that the idea of a trans-Pacific submarine cable was first discussed and considered by the late Cyrus Field, nearly thirty years ago. The scheme of Mr. Field and his associates involved a route from California via Alaska and the Aleutian Islands to Japan. Since that date, the subject in some form has been almost constantly before this country and England. This question has been discussed in the Fifty-second, Fifty-fourth and Fifty-fifth Congresses, in each of which effort was made looking towards laying a cable at least as far as the Hawaiian Islands.

In a special message to Congress, dated February 10, 1899, the President says:

"As a consequence of the ratification of the treaty of peace between the United States and Spain, and its expected ratification by the Spanish Government, the United States will come into possession of the Philippine Islands, on the farther shores of the Pacific. The Hawaiian Islands and Guam becoming United States territory, and forming convenient stopping places on the way across the sea, the necessity for speedy cable communication between the United States and all these Pacific islands has become imperative. Such communication should be established in such a way as to be wholly under the control of the United States, whether in time of peace or of war. At present the Philippines can be reached only by cables which pass through many foreign countries, and the Hawaiian Islands and Guam can be communicated with by steamers only, involving delays in each instance of at least a week. The present condition should not be allowed to continue for a moment longer than is absolutely necessary."

THE BRITISH PACIFIC CABLE.

The idea of a British Pacific Cable, connecting Canada with the Australasian colonies, almost from the first has been discussed from a national standpoint.

Her Majesty's Government and the colonial governments most concerned have been urged from time to time to consider the matter in its strategic and commercial aspects. Two colonial conferences in 1887 and 1894 were largely occupied with this subject, as evidenced by the exhaustive blue books which record their proceedings. The Dominion Government took the matter up in 1893-4, and invited the most reputable cable firms in the world to submit estimates for construction and laying.

In the proceedings of this conference, held in Ottawa in 1894, at which the Imperial Government, the Canadian Government, the South African Government, and all the Australasian Governments were represented, the following significant resolutions appear:

"Resolved: That in the opinion of this conference immediate steps should be taken to provide telegraphic communication by cable, *free from foreign control*, between the Dominion of Canada and Australasia."

"Resolved: That it is for the interest of the Empire that, in case of the construction of a cable between Canada and Australasia, such cable should be extended from Australasia to the Cape of Good Hope."

In 1896, Mr. Chamberlain, Secretary of State for the Colonies, appointed a Pacific Cable Committee which included among its members the Under Secretary of State for the Colonies, the High Commissioner of Canada, and the Agents-General for New South Wales and Victoria. This committee went into the whole subject of the practicability, cost, probable revenue, and management of the proposed enterprise, and elicited a fund of technical, commercial, and professional information upon cable laying in general, and upon this important project in particular, which is invaluable and which probably could not have been obtained in any other manner.

At this moment a Pacific cable touching only soil belonging to Great Britain is assured beyond a doubt, both Canada and Australasia having recently joined with England in pledging themselves to the enterprise as a government undertaking.

The proposed route with surface distances involved is shown on the accompanying map and is from Vancouver to Fanning Island, thence to the Fiji Islands, thence to Norfolk Island, and from there bifurcating to New Zealand and Queensland.

Owing to the great resources and experience of Great Britain in cable manufacture and the recognized urgent necessity of crossing the Pacific by cable, it may be taken as reasonably certain that the British Pacific cable will be in operation before any American cable can be laid, and the calculations and estimates in connection with this American enterprise should be based upon this supposition.

The history of the British Postal Telegraph and Cable Service in its gradual extension and perfection up to the present time, when nothing less than an Imperial Telegraph System connecting every British possession around the globe is projected, is a most valuable and interesting study for the United States. The British Pacific cable, now assured and authorized, is really but a first span in the larger Imperial cable system, which is ultimately to be constructed. This system which has been so ably and persistently advocated by Mr. Sandford Fleming, Engineer-in-Chief to the Canadian Pacific Railway, involves the laying of something like twenty-five thousand miles of submarine cables in the Pacific Ocean, Indian Ocean, and South-Atlantic Ocean, aggregating an expense of between five and six million pounds sterling. When completed it will be the most extensive and perfect telegraphic system in existence, placing England in direct communication with all her colonies encircling the globe, and with the following fortified and garrisoned coaling stations: Hong Kong, Singapore, Trincomalee, Colombo, Aden, Cape Town, Simons Bay, St. Helena, Ascension, St. Lucia, Jamaica, Bermuda, Halifax, Esquimalt, King George's Sound and Thursday Island; and also with the following "defended ports": Durban, Karachi, Bombay, Madras, Calcutta, Rangoon, Adelaide, Melbourne, Hobart, Sidney, Newcastle, Brisbane, Townsville, Auckland, Wellington, Lyttletown, and Dunedin.

Since a Pacific cable will at last complete the telepraphic circle of the globe, it will give the peculiar advantage of placing each point in cable connection with every other point by *two* distinct routes, either east or west.

Furthermore, this Imperial system, like the Pacific cable span, is to be operated, as well as laid, by the Government directly concerned, and is to form a direct extension of the present governmental land systems throughout the British Empire.

The cardinal idea in the British system has been that all state cables shall touch only British soil, and this principle has placed British cable traffic in the Pacific forever at a disadvantage over the American cable for the reason that the only available route involves a single span of cable from Vancouver to Fanning Island, over three thousand five hundred miles in length; whereas, by the annexation of Hawaiian Islands, the United States, while following a similar principle, will have no span longer than the present Atlantic cables, or about two thousand five hundred miles in length.

Since the speed of cabling decreases in general with the square of the length of the cable, and the speed of the whole system is limited by the speed of the slowest span, that system requiring the longest single span is ultimately at a disadvantage, provided the systems are in direct competition. In the Pacific cable enterprise projected, however, although, as will be pointed out later, they will operate in close relations with each other, yet each has a sufficient prospective traffic to guarantee the enterprise as a sound financial success from the beginning.

In June of this year a British Imperial Telegraph Committee was formed with Sir Edward Sassoon as chairman, which has for its object the consideration of the present high and in many cases prohibitory charges for telegrams to all parts of the British Empire, with a view to obtaining a reduction in the rates, and this committee has since collected facts and formulated a statement of the present condition of affairs. This committee represents Ceylonese, Chinese, Indian, and Australian associations of trade, the Agent-General of the Cape of Good Hope, the Agent-General of Victoria, and prominent members of Parliament who have shown special interest in the development of the British Empire.

AMERICAN CABLE ROUTES.

An idea of the present telegraphic method of reaching Manila is seen by the large number of repetitions required by the Eastern route.

Present route of cablegrams from Washington to Manila: To New York by land; to Valentia, Ireland, by cable; to Brighton, England, cable and land; to Havre, France, cable; to Marseilles, land; to Alexandria, Egypt, cable; to Suez, Egypt, land; to Aden, Arabia, cable; to Bombay, India, cable; to Madras, land; to Singapore, Malayan Peninsula, cable; to Saigon, Cochin China, cable; to Hongkong, cable; to Manila, Philippine Islands, cable. Distance 14,000 miles. Number of transmissions fourteen.

In the consideration which, from time to time, has been given the project of spanning the Pacific Ocean by a submarine cable, the Northern route via Alaska, the Aleutian Island, Siberia, and Japan has been frequently proposed. Cyrus Field and his associates, thirty years ago, investigated this route.

In recent years the British Government, in its proposed line from Canada to Australasia, first projected this northern route; this was owing to the absence, at that time, of information respecting the Southern Pacific Ocean, and the impression which prevailed that physical difficulties existed which offered insuperable obstacles to the laying of a cable on a direct route between Canada and Australasia. In consequence of this impression it was designed to lay the cable from Vancouver to Japan, touching at islands in the Aleutian and Kurile groups as mid-ocean stations. From Japan the connection with Australasia would be obtained via Singapore, and the Eastern extension Company's lines of telegraph. Through the intervention of the Home Government, negotiations were opened with the view of securing one of the Kurile Islands. Japan was asked to transfer to the British Crown one of these islands in order that the telegraph station would be under British protection, and an agent was sent to Washington, who, after some difficulty, obtained conditional landing privileges on one of the Aleutian islands.

Recently there has been a revival of interest in this route, especially now that the growing commercial interests of Alaska are becoming important. The plan proposes starting from Cape Flattery, thence to Sitka, distances (approximate) 803 miles; thence to Kadiak Island, 682 miles; thence to Dutch Harbor, 770 miles; thence to Attu, 810 miles; thence to the Japan-Russian border, 856 miles; thence to the Japanese land lines, 810 miles: from the Siberian border to Siberian lines 617 miles, and from Formosa to the Philippines, 200 miles, in all 5,550 nautical miles, exclusive of the Japanese system.

It will be noticed that this series of cables, aggregating 5,550 miles makes no provision for American communication with the Philippines, except over the Japanese land lines from the north point of Japan to the south point of Formosa, a distance through a foreign territory of about 1,200 miles.

Owing to the uncertainty of the Japanese land lines which are frequently interrupted during the typhoon season, particularly in Formosa, it would be necessary in order to insure uninterrupted communication to extend the Japanese cable system. Again, the Great Northern Telegraph Company, a Danish corporation, has exclusive rights, not only on the Siberian coast but also between Japan and the Asiatic coast. This company is in the great cable pool with the Eastern Extension Company, and it is not reasonable to expect that it would consider terms which would divert European traffic from its own extensive system to an American route. Even if the Great Northern Company permitted a landing in Kamchatka the operation of the Siberian land line is difficult and costly, while frequent interruptions make their service uncertain.

Apart from establishing telegraphic communication, free from foreign control, between the United States, the Hawaiian Islands, the Philippine Islands, and the Island of Guam, the mission of an American Pacific cable should be to bring about a general reduction of cable rates.

To attract European business a rapid, reliable, and economical service is necessary.

On the Alaskan route a large number of intermediate stations must be established and maintained; there must be a division of receipts with Japan, and this is in the face of a pool of the strongest telegraph companies of the world now under contract with the Japanese Government.

A message via Honolulu, an intermediate island station, and Guam would reach Luzon promptly by four cable transmissions. The Alaskan route would necessitate in the neighborhood of fifteen separate transmissions, of which about one-half would be by Japanese operators.

The recent acquisition by the United States of the Hawaiian Islands on one hand, and the Philippine Islands and the Island of Guam on the other, makes it an imperative necessity to lay a cable between the United States and Honolulu, and to connect the island of Guam and the Philippines with the United States. Furthermore, this entire cable will touch only American soil, and will not only be free from necessary concessions and mutual obligations which passing through foreign territory would necessarily entail, but also avoid all foreign complications.

Undoubtedly an Alaskan cable will soon be required, and undoubtedly also the extension of such a cable as a means of attaining a through line to the Philippine Islands is a plan on its face technically and economically attractive. But it leaves the United States in practically the same unsatisfactory position she is in at present in respect to communication with her Pacific possessions, and until definite and perpetual concessions are forthcoming, can furnish even no guaranty of substantial reduction from the present exhorbitant rates.

In the short time since the outbreak of the Spanish-American war, the United States has had experience respecting submarine cable communication in the control of foreign corporations. In Cuba, in Porto Rico, and in the Philippines, the United States is still confronted with complicated and novel situations involving concessionary and other rights. The War Department is paying over $100,000 annually to a foreign corporation for the transmission of its limited messages over the short span of cable, about six hundred miles in lengh, between Hong Kong and Manila. This is the interest at three per cent. upon about $3,500,000—approximately the cost of an entire Atlantic cable. An English corporation having exclusive cable rights in the Philippine Islands, previously granted by Spain, exacts a rate of seventy-five cents for every word transmitted from Hong Kong to Manila, which is three times the present commercial rate between New York and London or Western Europe. Furthermore, under this exclusive concession, the right of the United States itself to lay inter-island cables in the Philippine Archipelago, for war purposes, was immediately questioned as soon as it was learned that the Signal Corps cable ship *Hooker* was being fitted out for this purpose. It is evident that this contention could not be sustained by this Government.

These cable questions have become so important and complicated, and the interest of the United States in them so material, that the Chief Signal Officer of the Army in his recent annual report makes the following recommendations:

"International Cable Regulations.

"In connection with the proposed American-Pacific cable, it is desirable to call attention to the fact that the whole subject of the rights, privileges, and immunities of submarine cable property in time of war has been brought to notice during the Spanish-American war, and should properly be a matter of consideration for an international cable conference. Such a conference for the protection of submarine cables was held at Paris in 1884, and its proceedings transmitted to Congress by a message of the President under date of January 9, 1899, and was subscribed to by the United States in conjunction with twenty-five other principal nations of the world.

"Article XV, of this conference, however, specifically states that 'The stipulations of this convention shall in no wise affect the liberty of belligerants', which article leaves this important property in time of war without adequate laws to meet the complicated cases which are certain to arise.

"In view of the present enormous projected extension of submarine cable service throughout the world, aggregating in the British Empire alone an estimated cost of $30,000,000, such a conference as above referred to could properly consider other international cable matters which cable progress now demands. Among them is the entire revision and adoption of an international cable code, with a view to establishing a standard, uniform, and efficient method of cable communication to replace the large number of separate and individual codes now in use throughout the world. A single code language thoroughly classified, carefully selected with reference to the avoidance of telegraphic errors, in transcription and transmission, whether in American Morse or Continental, should be formulated and adopted by the leading nations of the world. Such a code would prove of great benefit, and its use would materially increase the efficiency of submarine cables."

With this limited but impressive experience available, it is believed that no one studying the true interests of the United States can come to any other conclusion relative to an American Pacific cable, than the one so admirably expressed by the President in his special message to Congress, viz., that this cable shall be "free from foreign control."

This cardinal idea,—the principle also adopted by Great Britain after years of exhaustive consideration—at once excludes the Northern route for the present, and limits the route to American soil.

PRACTICABILITY.

There is no longer any doubt as to the practicability of the Pacific cable project from a technical and engineering point of view. A preliminary survey between the coast of California and the Hawaiian Islands was completed by the Navy Department in 1892,* showing the entire practicability of this part of the route. Between California and the Hawaiian Islands several approximately parallel routes are practicable, but the one which seems to be favored by the survey of '92, as shown in the report of the Hydrographic Office of the Bureau of Navigation, is a rhumbline between Monterey Bay, California and Honolulu on Oahu Island.

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* See Senate Document 153.

The U. S. S. *Nero*, under command of Commander Charles Belknap, U. S. N., has been engaged since April last in a survey of the bed of the Pacific along the proposed route of the cable from the Hawaiian Islands westward to the Philippine Islands and to Japan. A preliminary report of this survey recently received, adds greatly to the knowledge of this part of the Pacific and to the data necessary before determining the exact route of the cable. This survey develops two unusual physical features along the route via Midway Island, one of these is a submarine mountain situated a short distance westward of the Midway Island, and rising from the floor of the ocean, having a depth of 2,200 fathoms, to within 32 fathoms of the surface. The second feature is one of the deepest submarine abysses yet found in the world, situated about five hundred miles eastward of Guam and more than 4,900 fathoms in depth. These and othef obstacles which may be found, however, can be avoided in laying the cable by making suitable detours around them as is ordinarily done.

A MID-OCEAN ISLAND CABLE STATION.

The great decrease in speed consequent upon increase of length of a single span of the cable, requires a landing station, if possible, between the Hawaiian Islands and Guam. The longest cable yet laid and in operation is the French cable from Brest, France, to Cape Cod, Mass., which is about 3,250 nautical miles in length, and there is no question that a cable directly connecting Honolulu and Guam could be successfully laid if no practicable landing place between these points could be obtained. This span, however, about 3,650 nautical miles including "slack" would for all time so reduce the through speed of the cable, and and so increase the original cost, as to warrant unusual expense, if necessary, in preparing and maintaining an intermediate station. In this connection the large amount of technical evidence given before the British Pacific Cable Commission relative to the Vancouver-Fanning Island span, which is practically this same extreme length of 3,600 nautical miles, and of the utilization of Fanning Island as a station;—are valuable as showing entire practicability. Although both Wake and Midway Islands, which have been proposed as stations, are low atolls, rising but a few feet above high water and with little to sustain human life, yet either of these places are equal, if not superior, to Fanning Island.

Further careful surveys will be necessary before the exact route west from the Hawaiian Islands to Guam can be finally determined. Fortunately for this enterprise the annexation of the Hawaiian group brought under the sovereignty of the United States eleven or twelve small, rocky or sandy islands extending to the northwestward about 1,800 miles from Honolulu. These must be surveyed and considered from the cable standpoint, before a final selection of the route can be made.

The distances in nautical miles along the proposed route, including ten per cent. for "slack" in laying, are as follows:

San Francisco to Honolulu,	2,286	miles.
Honolulu to Midway Island,	1,254	"
Midway Island to Guam	2,523	"
Guam to Dungala Bay, P. I.,	1,496	"
Total via Midway Islands,	7,559	"

San Francisco to Honolulu,	2,286	miles.
Honolulu to Wake Island,	2,205	"
Wake Island to Guam,	1,435	"
Guam to Dingala Bay, P. I.,	1,496	"
Total via Wake Island,	7,422	"

COST, MAINTENANCE, AND OPERATION.

The cost of laying cable depends mainly upon the materials used in its construction and therefore fluctuates with prices current. The outer coverings are much the same in all specifications, according to the condition of the case, but the copper conductor and the gutta-percha insulation vary with the speed required over the cable. Since the length of the longest section in this cable is approximately that of several of the Atlantic cables, the type of the cable to be used for this section, and the speed obtainable are subject to very close estimation.

Of the thirteen cables spanning the north Atlantic, the Anglo-American Company's cable laid in 1894, and the Commercial Cable Company's cable No. 3, laid also in 1894, have the greatest speed.

Either of these types of cable would give good results, and no cables of less equivalent speed should be considered.

The following conservative estimate is made from the evidence obtainable relative to the establishment of this enterprise on a sound financial basis:

Maintenance and Repair per Annum.

Annual expense of two cable repair ships, . . .	$200,000
Annual expense for new cable, assuming entire cable to be replaced in 40 years, or 200 miles yer year, ...	200,000
Working expenses	125,000
Reserve fund and interest on capital, ...	400,000
Total net earnings of cable required, ...	$925,000

This provision for laying 200 miles of new cable per year should perpetually maintain the value of the cable as an asset, and the reserve fund further provides that the entire capital shall be replaced at the end of fifty years, or what is equivalent, that a sinking fund shall be provided, which at the end of fifty years will be sufficient to lay an entire new cable in addition to the permanent maintenance of the original one, so that at the end of fifty years, two working cables will be provided for.

At present there is no first class cable ship in the world flying the American flag, and which would therefor be under the control of the United States in time of war. It shoud be the policy of the United States, whether the Pacific cable is laid by the Government, or by a subsidized company, to require that two complete cable repair ships, one at least also capable of laying long cables, equal to any yet constructed for these purposes, and flying the American flag, be stationed in the Pacific Ocean.

Assuming a general type of cable equivalent to those mentioned above:

Total carrying capacity per annum in paying code words of eight letters each, allowing 30% for waste, 11,800,000.

Average cost of transmission per telegraphic code word of eight letters about eight cents.

Present commercial rate from Washington to Manila $2.38 per word, Government rate $2.255 per word, and the rate for "right-of-way" messages three times the normal rate.

It is seen that at the present commercial rate to Manila, after allowing for present land rates to San Francisco, the proposed cable is required to operate less than fifty minutes per day in order to earn the required income of $925,000 per year. Allowing the present rate to be reduced one-half the cable would have to work less than two hours daily.

If the rate per code word of an average of eight letters is placed at fifty cents from San Francisco to Manila, then, upon the above supposition the cable need operate daily less than four hours to put the enterprise upon a sound financial basis.

The desirability of the cable from an economic standpoint seems unquestioned. The Secretary of War says in his annual report: "The cable tolls of the War Department messages alone to and from the Philippine Islands for the last five months have averaged $27,114.12 monthly, a rate of over $325,000 a year." This alone equals the interest at three per cent. on the sum of $10,845,000. It is reasonable to assume that the despatches of the other departments of the Government would at least increase this amount by one-quarter, which would make the present Government cable tolls to and from the Philippines equal to the interest at three per cent. on approximately $13.500,000. Fully ninety per cent. of these sums go to foreign corporations, while all Pacific cable expenditures would remain in the United States.

PROPOSED MANAGEMENT OF THE CABLE AS A GOVENMENT ENTERPRISE.

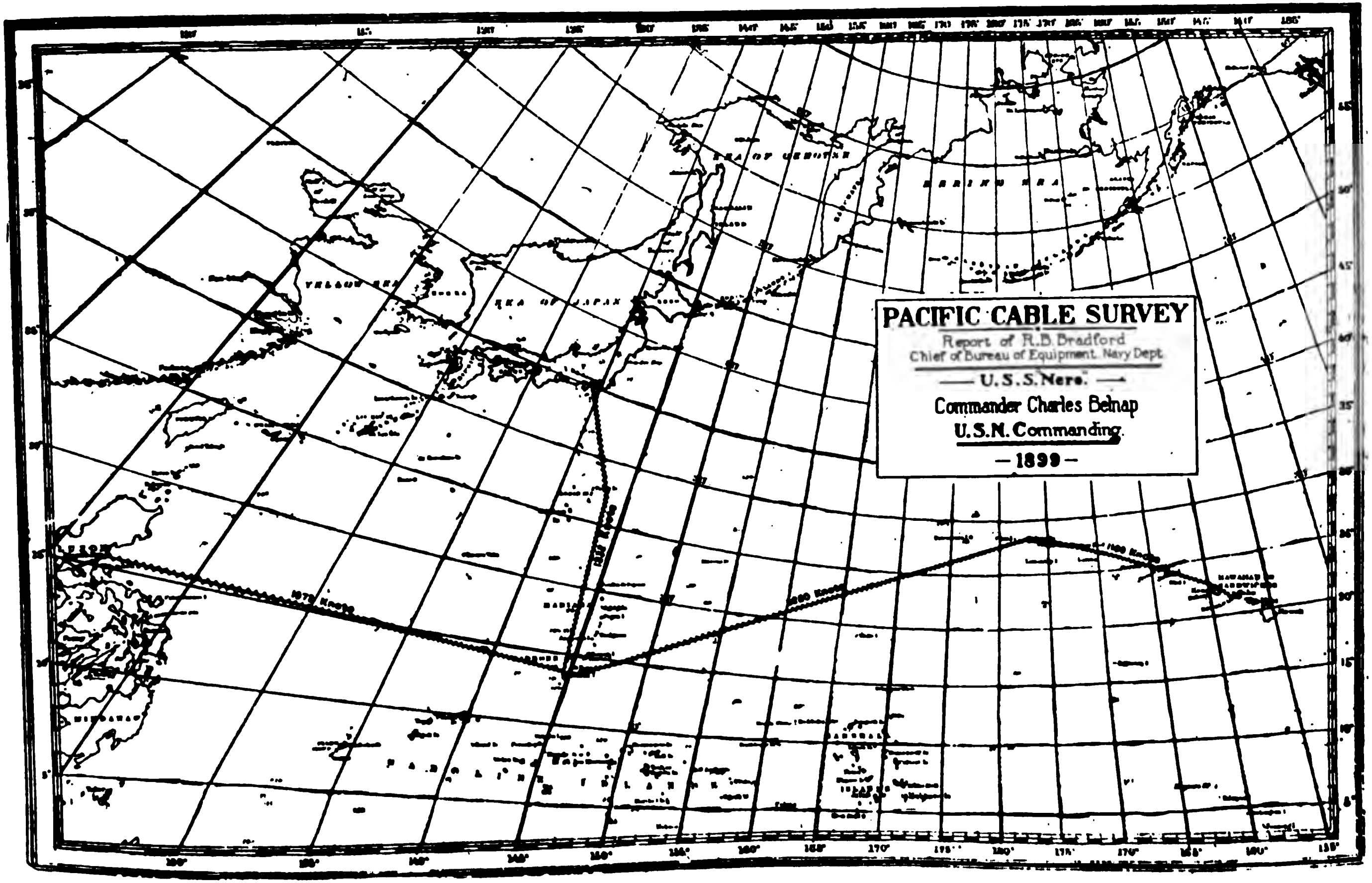
It is not proposed to enter here into a discussion of the subject of the Government control of telegraphs, although it is believed that the time will come when the mail, the telegraph, and the telephone will be combined for a public service under a single management, with an efficiency otherwise impossible. The transmission of letters has always been wisely held to be a function of the State, and it has also been determined by every country in Europe that so efficient a servant to the people and trade as the telegraph should be a national institution. England, France, Australia, Germany, Russia, Italy, Spain, Portugal and Belgium have each established a state telegraph system. In England the telephone service is not entirely under the control of the Government. The trunk lines are so controlled and operated, leaving to private companies the service in local districts.

In a country where the three great branches of intelligence transmission, the mail, the telegraph, and the telephone, are under one management, special advantages to the people are obtained which are not realized when these departments are separated. In England, for instance, messages may be telephoned:

(1) For transmission over the postal telegraphs and delivery as telegrams.

(2) For delivery as express letters.

(3) For transmission and delivery as ordinary letters.



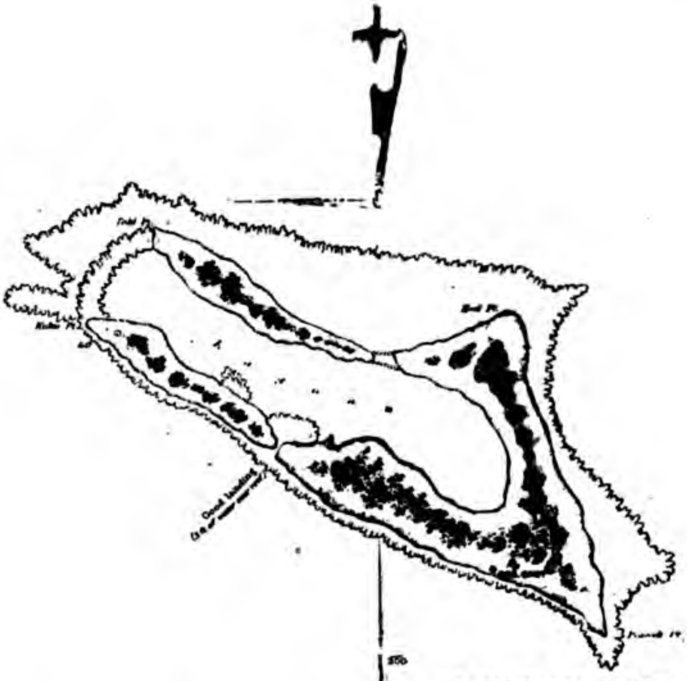
PACIFIC CABLE SURVEY

Report of R. B. Bradford
Chief of Bureau of Equipment, Navy Dept.

— U. S. S. Nero. —

Commander Charles Belnap
U. S. N. Commanding.

— 1899 —



WAKES ISLAND

BY THE

U.S. EX. EX.

1841.

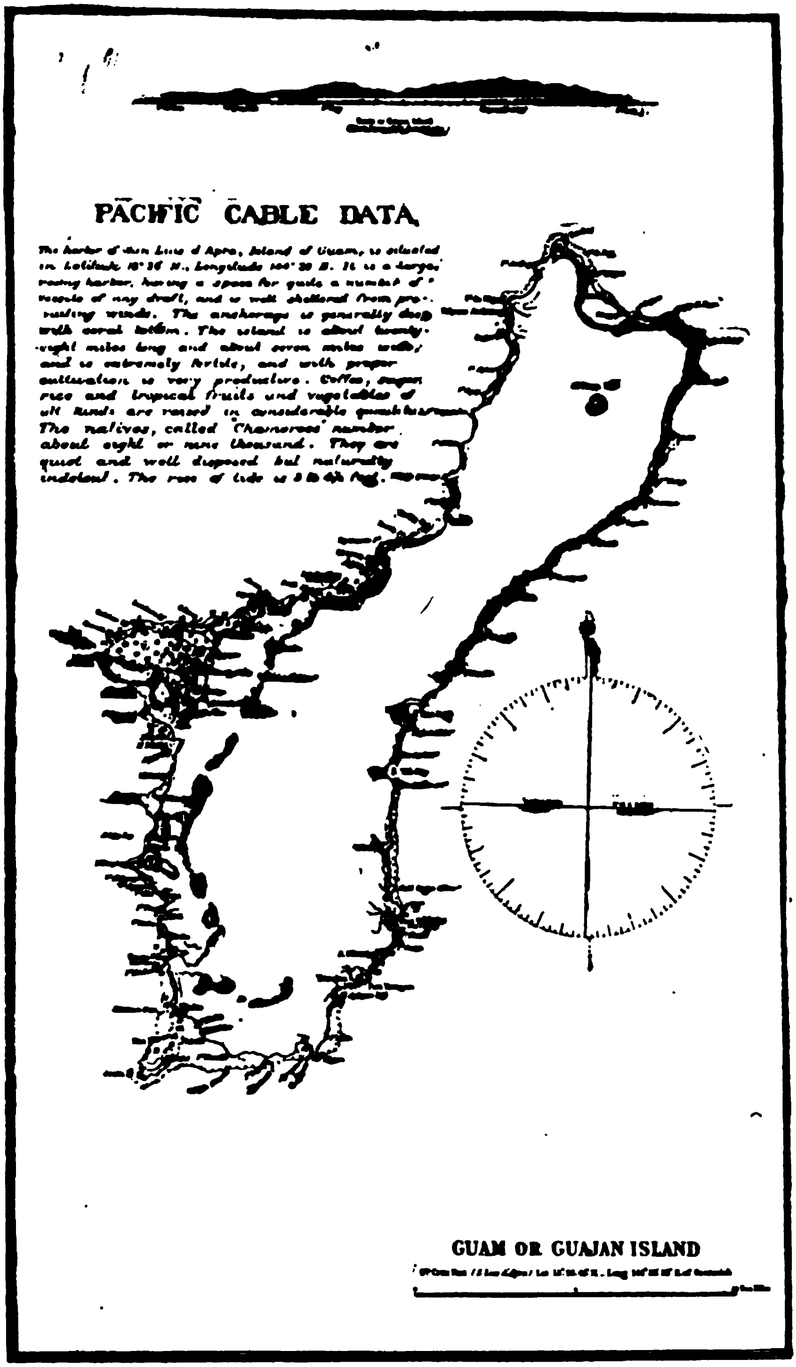
With additions by Brig. Gen. F.V. Greene, U.S.A., in 1898.

Obs. spot, Lat. 19°15′ (00″) N. – Long 166°33′ (00″) E.
Variation 8°03′ E. 1898.
The Island is from 5 to 15 feet above high water.
Rise of tide about 6 feet.

Scale

PACIFIC CABLE DATA.

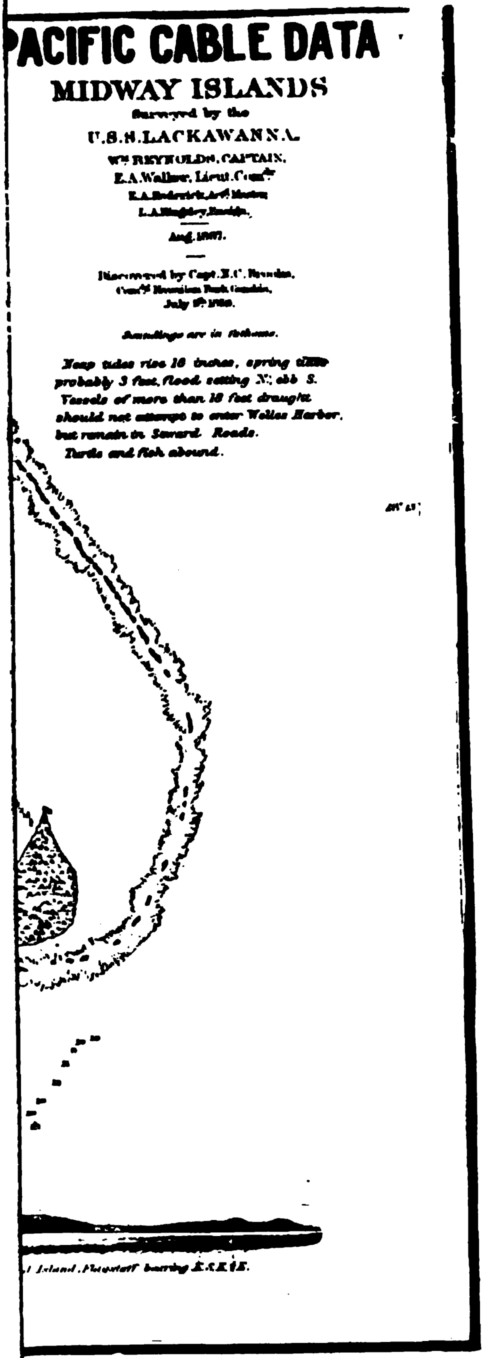
Wakes Island is situated in Latitude 1[illegible] N, Longitude 166°31′ E. It is a low, sandy island, about three miles wide and five miles long, enclosing quite a large lagoon. Its elevation above the sea is from five to fifteen feet above high water, the rise of tide is about six feet. There is no fresh water on the island and only a slight vegetation of stunted trees. The island is surrounded by reefs on the east, west and south sides, and possibly on the north, which is not explored. The island is probably swept with spray and possibly with breakers during heavy storms. There are no inhabitants.



PACIFIC CABLE DATA

The harbor of San Luis d'Apra, Island of Guam, is situated in Latitude 13° 26 N., Longitude 144° 39 E. It is a large, roomy harbor, having a space for quite a number of vessels of any draft, and is well sheltered from prevailing winds. The anchorage is generally deep with coral bottom. The island is about twenty-eight miles long and about seven miles wide, and is extremely fertile, and with proper cultivation is very productive. Coffee, sugar, rice and tropical fruits and vegetables of all kinds are raised in considerable quantities. The natives, called "Chamorros" number about eight or nine thousand. They are quiet and well disposed but naturally indolent. The rise of tide is 3 to 4½ feet.

GUAM OR GUAJAN ISLAND



PACIFIC CABLE DATA

MIDWAY ISLANDS

Surveyed by the

U.S.S. LACKAWANNA.

Wm. REYNOLDS, CAPTAIN.

E.A. Walker, Lieut. Comdr.

E.A. [illegible], Act'g Master

L.A. [illegible], Ensign.

Aug. 1867.

Discovered by Capt. N.C. Brooks,

Com'g Hawaiian Bark Gambia,

July 5th 1859.

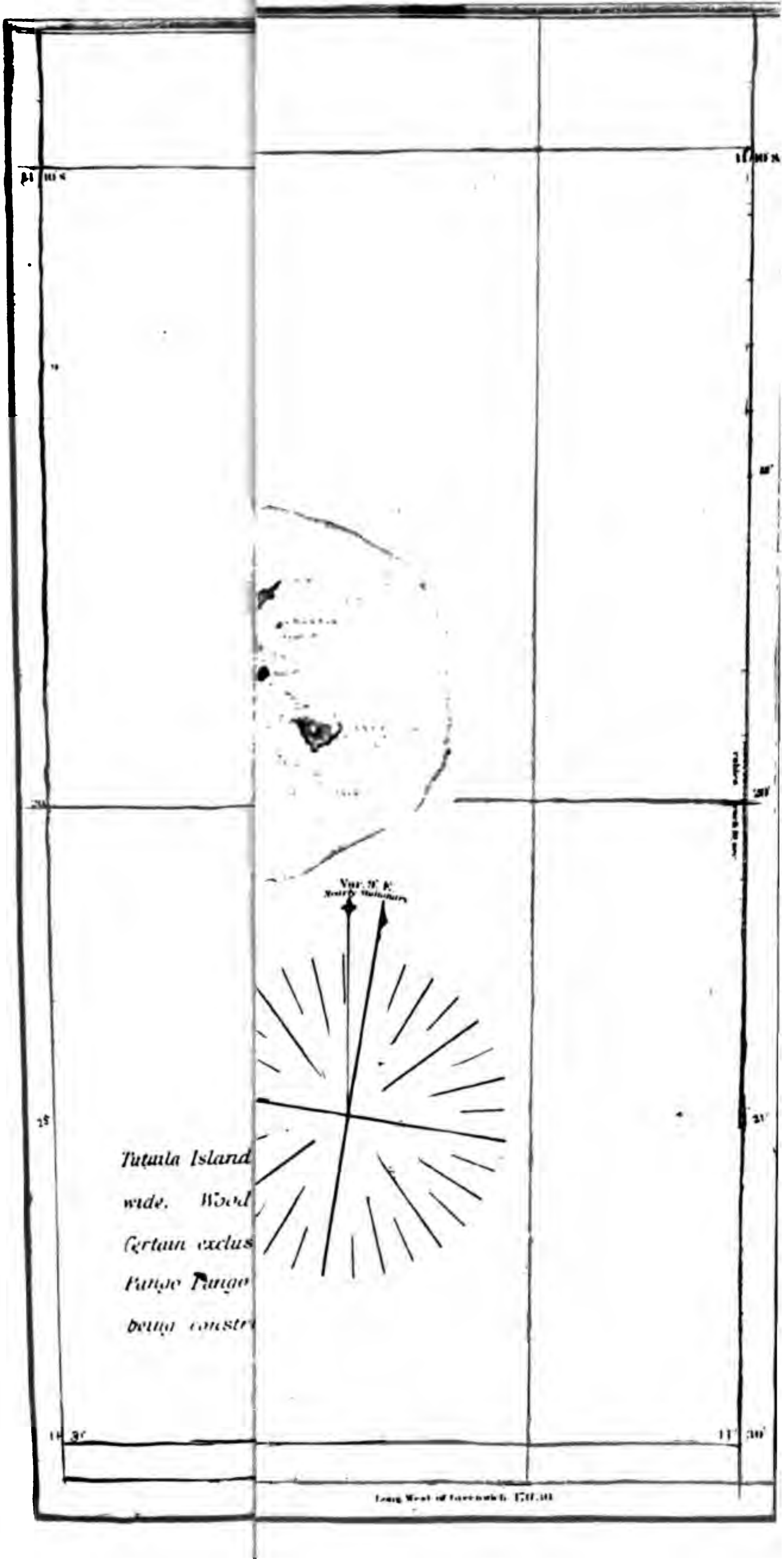
Soundings are in fathoms.

Neap tides rise 18 inches, spring tides probably 3 feet, flood setting N.; ebb S.

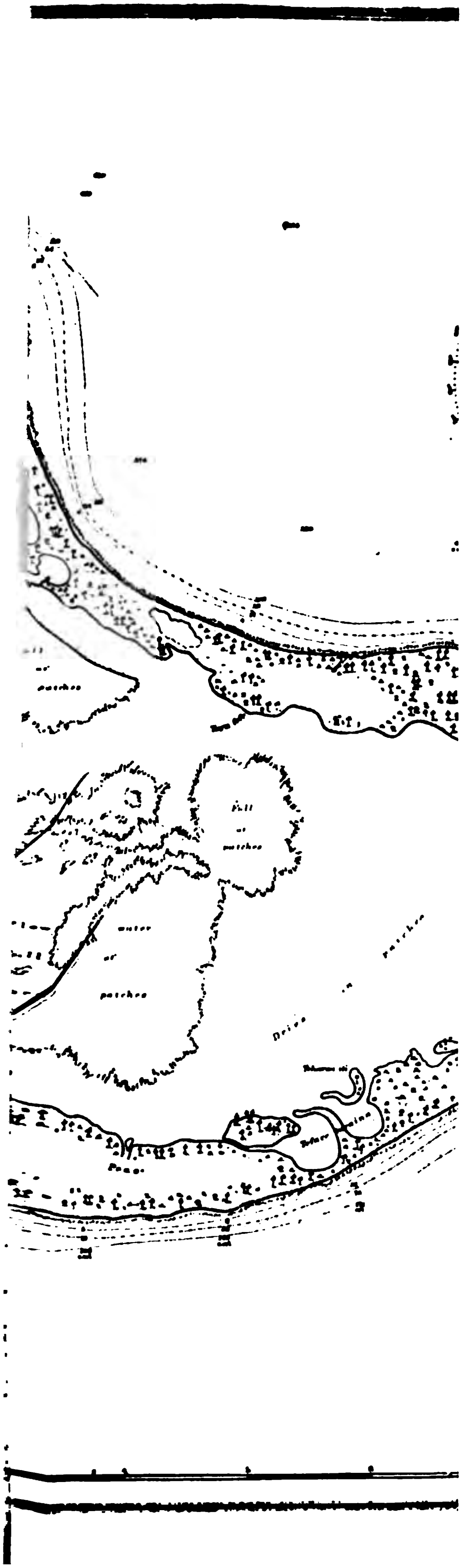
Vessels of more than 18 feet draught should not attempt to enter Welles Harbor, but remain in Seward Roads.

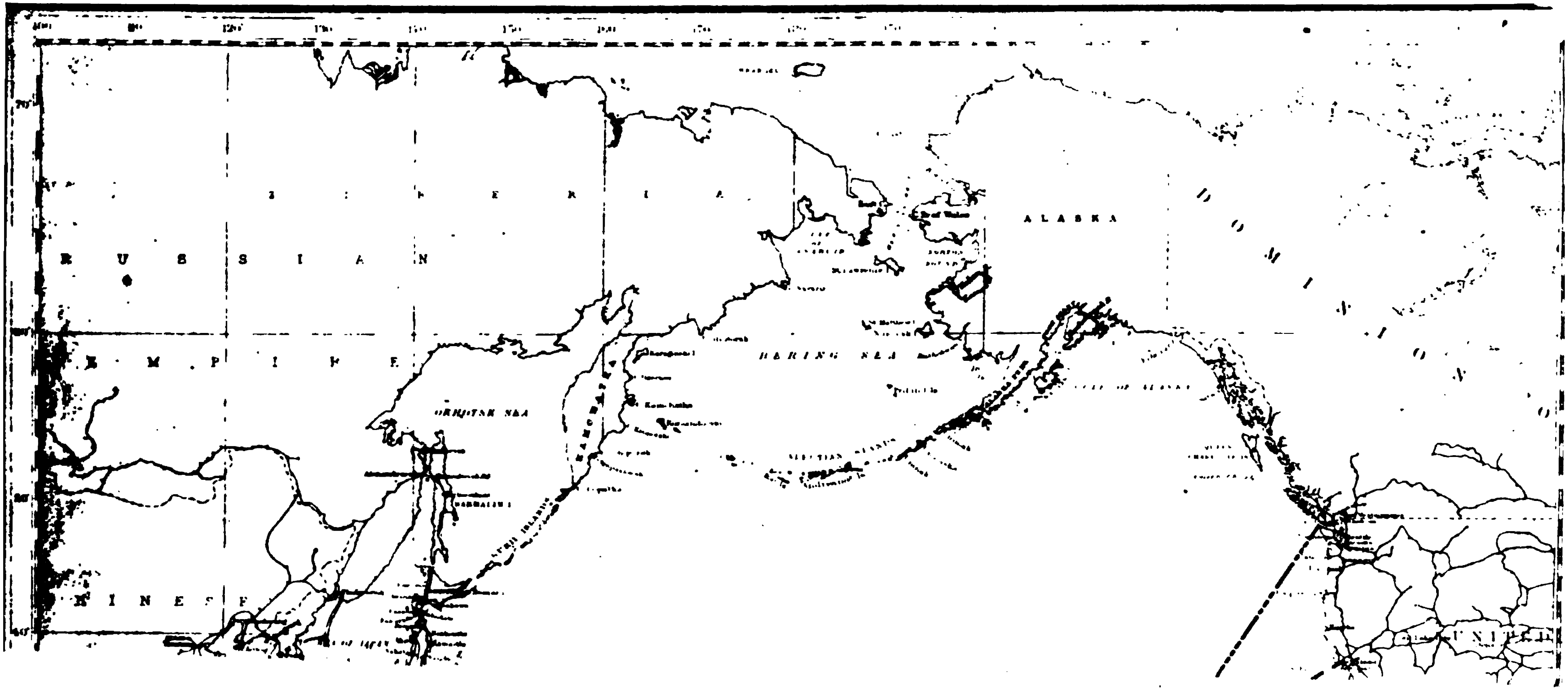
Turtle and fish abound.

l Island. Flagstaff bearing E.S.E.½E.



Tutuila Island
wide. Wood
Certain exclus
Pango Pango
being constr


or
patches
Fell
or
patches
water
or
patches
Drive
patches


RUSSIAN
SIBERIA
EMPIRE
CHINESE
OKHOTSK SEA
SAGHALIEN
KURIL ISLANDS
KAMCHATKA
BERING SEA
ALEUTIAN ISLANDS
ALASKA
DOMINION OF
UNITED

The telephone may also be used for obtaining the service of post office express messenger.

If there are reasons which have placed the land telegraph systems throughout Europe under the control of the State, the same reasons are more potent in extending such control to cables binding a country to her island possessions; and if there are reasons which have laid state cables in the past and are at present projecting an extension of such cables throughout the world to an unprecedented magnitude, the cable finally to join the two hemispheres together in the bed of the Pacific and linking together a chain of American possessions to the very door of the East, should be established as a great national public work.

The successful operation of any ocean cable system requires the use of a land system covering the territory at each of its extremities. If not actually in combination with these land systems some mutual and very close business arrangement must be effected. In the Atlantic ocean cable system rival corporations actually own each its co-operating land system in the United States. The equitable routing of traffic and division of tariffs between the different corporations concerned are difficult and complex. If then, the proposed Pacific cable is operated by a private corporation it is plain that the more or less close combination with particular land corporations will necessarily result as in the past, and will operate to enlarge and perpetuate rather than break down the present high tariff rates. It is believed that it is only by Government control of the cable through a Commission, whose management is open to the scrutiny of the people, that free competition on land can be accorded which shall apply equitably to all American telegraphic corporations, and discriminate neither for nor against any individual, association, or corporation.

Assuming that the proposed Pacific cable will be established by the Government, opportunity will be presented in this new and unoccupied field of the Pacific, unfettered by precedent and obligations, to introduce such radical changes in the policy and business management of the enterprise as will operate advantageously to the people directly concerned, and for whom the cable is primarily built. Private corporate management naturally aims at large dividends for its stockholders. Cable rates throughout the world are excessive, and defeat in a great measure the true international and intercolonial objects for which such cables should be established. It is a matter of statistics that in cabling throughout the long distances involved in the East, out of every one hundred messages sent, ninety-nine are purely commercial in character and but one of private nature. Cabling throughout the world is to-day so expensive that it is only resorted to for urgent commercial purposes.

The present tariff rates strictly limit the kind of traffic offered, prohibit all other than that of the most urgent nature and are sufficiently high to keep the long cables actually idle for a considerable portion of each twenty-four hours. And why should any cable binding a country to her colonies, spanning an ocean and connecting two continents together ever be permitted to be idle? Is it because these countries have nothing to say to each other? The enormous volume of the present mails effectively answer this. The world's cable plant could be duplicated many times and all kept full to overflowing if the cable rates were sufficiently reduced.

ELECTRICITY THE IDEAL MEDIUM FOR TRANSMITTING INTELLIGENCE.

The triumphs of science in the last half century have been nowhere more exemplified than in the enormous strides made in the facility of transmitting intelligence. The mails, the telegraph, and the telephone are civilizing the world. Perfect as is the mail system of to-day, a monument to organization, yet, its swiftest messenger—steam—is so far outstripped either on land or sea by the practically instantaneous electric current, that the tendency year by year is to put more of the world's business "upon the wire." The time is fast approaching, let us hope, when a telegraph and cable letter service at rates comparable with present postage rates will be realized throughout the world, with its consequent revolution in business and social methods. Time has an international money value. The fastest mail express or the swiftest ocean mail ship are as naught compared with the velocity of the electric impulse which practically annihilates any terrestrial dimension. As the distance increases, electricity surpasses steam in a continuously increasing ratio. In the case of a message to be sent across the street, probably there is no more efficient and satisfactory method than by a mail delivery messenger, but if this message is to be sent half way around the earth, the minutes required by the telegraph run into weeks and months by the slow process of the mails. Steam time is directly a function of the distance to be traversed, and from the nature of things must require twice as long to go two miles as one. If then the cable saves six days between Europe and

America, it will save more than twice this time between America and the East, and is from this point of view correspondingly important and necessary. Since electricity so far outstrips any other known vehicle for transmitting intelligence, it must eventually carry all the important information and practically take from the present mails more and more of its most urgent letters.

CONTINUOUS USE OF THE CABLE PROPOSED.

With a Pacific cable laid and in operation, and possessing such insurmountable advantages over the mail, how can any management be entertained which does not aim at the use of the cable continuously to its fullest capacity? The cable property is peculiar in that it does not, like mechanical machinery possessing moving parts, deteriorate with use, and its life is not therefore dependent upon the amount of traffic transmitted. The ordinary manufacturing plant is usually not operated continuously because the coal consumption, the wear and tear of machinery and the extra expense of employees, combined with the state of orders received, do not present a sufficiently attractive economical proposition. But a large cable property presents unique conditions from a purely business standpoint. The bulk of the capital invested is buried under the sea and much the largest item to be earned is the interest on the capital. A two thousand mile line requires but two operating stations, and the annual expense of the few clerks who actually operate the plant forms a comparatively insignificant part of the total annual expense of the plant.

In the estimate of Mr. Alexander Siemens upon the British Pacific cable, at Ottawa in 1894, but 12% of the total annual expense was for clerk staff, and this also provided for more than double the usual wages in consideration of the isolated positions of the mid-ocean stations.

Add to this the fact that what ordinarily corresponds to coal consumption here consists of a few electric batteries and is therefore practically nil, and also the fact that using the plant causes no deterioration, and the logical business conclusion is reached, that ocean cables should be kept busy continuously. Every hour they remain idle is so much service absolutely lost. But present practice places cable tariffs so high as to force to idleness for a considerable portion of each twenty-four hours all the long cables of the world. In addition the Atlantic cables are practically silent one day in seven.

In defense of the present management, too often unjustly accused, it is submitted that cable property on the whole has been particularly hazardous and uncertain, repairs often most expensive, and a prudent management has required large sinking funds and reserves. Furthermore, the necessary traffic arrangements required with co-operation or competing companies establish precedents and form obligations not easy to suddenly change. The whole of cable history does not yet cover fifty years. But the skill and experience of the large cable manufacturers in England have brought this industry to such a state of perfection that the laying of a two thousand mile ocean cable, or its repair in three thousand fathoms, is no longer considered a particularly hazardous undertaking. In fact, in the beginning, cable rates had to start high, and although there has been a steady decrease in rates to the present, as the technical side of the business has become more stable and certain, yet it is believed that the time has now arrived when a more extensive classification and reduction can be inaugurated with advantage both to patrons and to revenues earned.

As a practical means for operating the cable continuously it is naturally suggested to classify the traffic offered and establish differential rates therefor, as is now universally done on land lines. The same causes which have established *night rates* on land are much more potent in case of ocean telegraphy, where the time gained and the capital invested per mile is enormously greater. It is simply a matter of paying for time. The stock exchange message where minutes are valuable should pay the highest rate, while less urgent business messages should be classified and paid for according to the time limit called for in delivery. Since the only other competitor in the Pacific is the mail steamships where the minimum time is over two weeks, it should be easy both to create new business and to draw from the mails as desired. In handling certain classes of messages it can be distinctly agreed to deliver only within a certain number of hours, or a week, or even establish a low Sunday rate for certain classes of matter, and still arrive much ahead of the letter sent by mail. If we have no less than four classes of matter in the present mail system by steam trains, why not a classified service for an ocean cable postal system where the reasons for it are more potent?

For the fiscal year ending June 30, 1898, the amount of mail matter, letters proper, excluding all other forms of mailable materials, carried in mail steamers from the United States across the Pacific Ocean for Japan, Hongkong, Shanghai, Manila, Singapore, Cochin China, Java, and Siam was about 10,948,651 grams, representing about 1,156,176 letters. From the United States for Hawaii, 3,495,442 grams, representing about 369,072 letters.

This reveals the appreciable proportion of the Pacific traffic which stops at the Hawaiian Islands, being from the above figure about 25% of the entire traffic which in 1898 left the United States for these countries. These figures are instructive as indicating that in considering the through trans-Pacific cable, the Hawaiian traffic is not entirely to be ignored, and that of the entire length of the cable, the span between California and Hawaii will continually be required to carry a materially greater portion, and will therefore be the first span requiring duplication.

Assuming that the carrying capacity of the proposed cable is equal to that of the best Atlantic cables for corresponding lengths, it is of interest to obtain in a general way the amount of traffic which can be handled across the Pacific under a management which insures the cable being used continuously. A conservative estimate, based upon the best evidence at hand, leads to the result that the proposed cable should possess a carrying capacity each way per annum of about 5,900,000 code words of eight letters, and this allows 30% of the entire amount as waste or non-paying traffic.

This means that of the 1,156,176 letters which in 1898 were trasmitted to Japan, Hongkong, Shanghai, Manila, Singapore, Cochin China, Java and Siam, this entire number could have been transmitted by cable, allowing for each communication about five words of eight letters each. Since the use of code books for all cable messages has so much increased that practically all cabling is now transmitted in this manner, we can reasonably take one word equivalent to five by their use, so that each communication above referred to is equivalent to twenty-five words of average length.

AN ANGLO-AMERICAN CABLE SPAN IN THE MID-PACIFIC.

All important submarine cables should be duplicated as soon as possible. Cables are always liable to interruption from a variety of causes and the interruption of the single line necessarily suspends all communication. The protection of the patronage requires duplicate lines if for no other reason.

An adequate plan for a Pacific cable should consider means for the duplication of the line as soon as possible. In this connection the Pacific Ocean and the route of the proposed British

Pacific Cable from Vancouver to Australasia, suggested a desirable span of cable of international value. Reference is made to the desirability of connecting Hawaii and Fanning Island with an Anglo-American cable, operated by the Governments concerned, under rules mutually acceptable. The Pacific Ocean, let us hope is soon to be spanned by two distinct ocean cables, each to touch soil exclusively owned or controlled by the Government interested, each, for intercolonial reasons, to bind a great country to her distant colonies and each, we predict, to be operated and managed upon broad lines as a government enterprise. A common interest should lead to the linking together of these two great ocean telegraphic routes in the mid-Pacific.

With this single span of cable laid, which is but about nine hundred and fifty nautical miles in length, or but thirteen per cent. of the length of either of the main lines, it results that each country has practically secured a duplicate to its line and insured it against a total interruption until such other lines can be constructed and laid as the growth of business will undoubtedly warrant.

Thus in case the British Cable between Canada and the mid-Pacific should be interrupted, it will be only necessary to route the British business for Australia arriving at Vancouver over the United States land lines to California to be transmitted over the United States cable to Hawaii, thence over the international span to Fanning Island and on to Australia via. the British line; or in case the American span to Hawaii is intterrupted, the United States can reach these islands and the East by routing traffic to Vancouver for transmission to Fanning Island, and thence to our trans-Hawaiian cable via the international cable span.

In a similar way, in case any section of either through cable is interrupted beyond the Hawaii-Fanning span, the urgent United States traffic can be routed from Hawaii westward via Australia, and thence to the East, or the urgent British business can reach Australia via Manila.

It is believed that such a living and equitable arrangement can be effected in the working of these Pacific cable systems as would afford security to each, and result in mutual traffic advantage to both enterprises. Thus, there is no reason why the present Atlantic cable system and the United States land systems, should not eventually serve as material feeders to and from Australasia, and likewise the British and Canadian systems supply an appreciable traffic to the Philippines and the East.

In case of war with any country other than Great Britain, having possessions in the East, the additional insurance afforded by this link of cable to constancy and control of our communications with the Hawaiian Islands, would be of the utmost importance.

CABLE CONNECTION WITH THE SAMOAN ISLANDS.

The interests of the United States in Samoa will be more clearly defined by the acquisition of sovereignty over the Island of Tutuili now reported probable. In this connection another branch of cable is suggested which the United States could properly assist. The new coaling station now building at Pango Pango (Pago Pago) Harbor in Tutuili Island is the advanced United States position in the southwestern Pacific, and from a strategic point, if no other, it is important that this coaling station should be in cable communication with the United States. As shown upon the accompanying map, a span of cable but six hundred and fifty miles in length connecting Fiji with Apia would thus join the Samoan group to the main British Pacific cable route and furnish cable connection for the three Governments interested, viz., England, Germany, and the United States.

THE STRATEGIC VALUE OF THE PACIFIC CABLE.

The control of the seas along the great natural lines of national commerce is chief among the material elements which contribute to the power and prosperity of nations. The sea is nature's highway. It is the land that divides and the sea that binds together. The narrow neck of land connecting the North and South American continents has stood for centuries a barrier to the ships of the world and has cost commerce millions in treasure.

The possession of the Hawaiian Islands by the United States has a far greater future importance than mere import and export statistics can ever indicate.

Suddenly, as if by magic, the leading powers are evidencing unusual interest in the Pacific and the East, and are seeking hitherto unimportant islands wherever situated.

In these days of "spheres of influence" the Hawaiian Islands occupy a unique and a paramount position.

Geographically, Honolulu is the center of a circle of approximately twenty-one hundred miles radius within which, excepting only a few isolated and barren islands, nature has placed a vast ocean expanse with no land. This circle includes San Francisco on the east, a part of the Aleutian Islands on the north, and the Samoan Islands on the south-west. Again, if the center of the circle is placed at one of the islands of this same group to the north-west, such as Midway Island, a possible station for the Pacific cable, an approximately equal radius includes the Island of Guam, now in the possession of the United States.

Hawaiian inter-island communication being now assured, this group of islands extending nearly two thousand miles in longitude, and standing alone over two thousand miles from continental mainland, defines a natural "sphere of sea influence" in the north Pacific of incalculable value to the future of the United States.

The importance of the geographical position of this group is only properly determined by reference to the changes in the great trade routes which will result from the Isthmian canal. Whether ultimately at Nicaragua or Panama, the immense merchant fleet, which will pass through this gateway, will find the Hawaiian group upon its direct course to the East, and at such steaming distance as to naturally require this as a mid-ocean stopping place. Again, the British-Canadian commercial route to Australasia, along which the British Pacific Cable is projected, as well as the direct mail and trade route from the Pacific States to the Philippine Islands and the East, both naturally pass through these islands.

It can be stated that there is scarcely any point in the world where there is greater need for a central cable station than in the Hawaiian Islands. Geographically situated at the military and commercial strategic position of the north Pacific Ocean, it will ultimately serve as the distributing center for ocean communication between the two hemispheres as well as to the various island groups of the Pacific.

Although it is said that cables are primarily established for peace rather than for short periods of war, yet in these advanced American outposts, extending in a chain to the Philippines in the East, and to the Samoan group in the Australasian south-west, the demands of both peace and war happily coincide.

Control of the sea requires not only ships, naval bases, and coaling stations, but the most efficient means of communication obtainable by which only can each and all be effectively employed.

The lack of effective communication under the exclusive control of the United States permitted a fleet of Spanish ships in our own waters to evade the vigilance of our entire home fleet for a considerable period during the Spanish-American war, and to spread alarm from Maine to Florida.

Submarine cables are now established for colonial, political, and diplomatic reasons as really as for their purely commercial purposes. Nor is actual state of war of the country itself the only fear: witness the present plight of France due to the Transvaal war; owing to the fact that the cables to South Africa are under the control of England, and the establishment by her of a war censorship, France is absolutely dependent upon England not only for news from the Transvaal, but also for communication with her own colony of Madagascar and her South Africa possessions. The importance of this subject has led her Colonial Commission to recommend recently the immediate construction of submarine cables joining France with Senegal, Madagascar, and Tonkin, the latter connecting with the Danish company's cables. Indeed, the plan ultimately involves an estimated expenditure of twenty-five million dollars and includes a complete colonial cable system.

A leading English authority has recently stated that the value of the English Navy is increased fully one-half over what it would be considering the number and power of her ships, by the complete system of submarine cable communications connecting her colonies, coaling stations and fortified ports and wholly under British control.

By whatever method the first Pacific cable is ultimately laid, and provided that it shall appear that all of the present projected cable can not be manufactured and laid in the United States within a reasonable time, it seems plain that the encouragement of American manufacture in the building up in the United States of a deep-sea cable industry of the first-class is a wise policy for this government.

CONCLUSION.

It is believed that it will soon be possible to telegraph to any part of the world at comparatively trifling expense. The science and art of transmitting intelligence in all its forms is at present making tremendous strides, the full significance of which it is not easy to appreciate.

From its very nature associated with every trade, industry or profession, facility of intelligent transmission is the direct means of controlling the energies of the world and establishing nations in their particular places in the scale of civilization.

After several years of comparatively little advance, the technical and scientific side of telegraphy has received much attention during the past two or three years, until at this moment there is no other special branch of electrical engineering which is more in evidence or promises more for the future.

From the diplomatic standpoint a complete revolution in methods has been brought about by the telegraph and submarine cable. The diplomatic relations between one country and another are now conducted with a facility and rapidity which has often been the means of averting international ruptures and consequent wars.

The successful completion of the submarine cable across the Pacific will mark an epoch in the telegraph history of the world. After thirty years of consideration—technical, commercial and political—the end of the century sees this great enterprise at last seriously undertaken. The full influence which it will exert upon the Western Hemisphere and the world in general is not easily appreciated. Strategically the importance of the inter-colonial communication and its preservation are very great; however, the Philippine question should not overshadow the larger question—the Eastern question—in the consideration of this project. Important as the cable will be as a means of joining the Philippine Archipelago to the United States, its larger importance will ultimately be in the future of the commercial development between the United States and the East. In the broad extension of the Pacific trade consequent upon the completion of the Isthmian Canal, and the development of steamship lines plying the Pacific, the telegraph cable would naturally become an important factor. The trans-Pacific steamship lines are heavily handicapped by absence of direct means of telegraphy between the ports between which they operate. Situated on the main trade routes leading from the canal to Asiatic ports, the Pacific cable will serve as a powerful adjunct and support to this enterprise. The two go hand in hand and are mutually closely related. As to the probable traffic to be immediately expected there is little direct evidence at hand, since the waters spanned have never before been crossed by a submarine cable. Taking the average earning power per nautical mile of the long cables of the world as a basis, this project should prove a paying investment from the very first, but it is believed that this estimate, based upon the average of cables will prove under rather than above experience, particularly as this route will immediately enter as a competitor for European traffic via the Atlantic and the United States land lines. The present rate from Washington to Manila is $2.38 per word, or $2.25 per word for Government business, and for special messages, which have the right of way, a rate of three times this amount is charged. The immediate effect of the trans Pacific cables will be to lower the rates to the East, since European traffic will be open to competition east and west and the new Western route, due to the long spans and comparatively few repetitions, will have an advantage.

Furthermore, a short span of cable laid between Luzon and Formosa connecting with the Great Northern Telegraph Company's route through Siberia will tend to this reduction. In fact, the laying of a Pacific cable will operate to re-adjust the present cable through-tariff throughout the world upon a lower basis. For instance, in the evidence before the British Pacific Cable Committee it is shown that the placing of messages from London to Vancouver over the Canadian Pacific line is already pledged at one shilling per word which is the present Atlantic cable rate alone. This means that European messages can be laid down in San Francisco at this rate or twenty-five cents per word. Even placing the tariff from San Francisco to the East at one dollar per word, which in a probable maximum, it would establish a $1.25 western rate from London at once whereas the present rate east is as follows:

London to Luzon	$2.10 per word.
London to China, via Eastern Indo or Northwestern (Siberia) or Northern Helampo.	
Macao	1.41 per word.
All other offices	1.35 " "
London to Japan, via Northern (Siberia)	1.51 " "
via Eastern or Indo	1.90 " "

The new line is therefore a formidable competitor for European traffic via the present Atlantic cable system in addition to its legitimate traffic from the United States.

The deep interest of Japan in the proposed cable is natural and logical. A short cable of about two hundred and fifty miles in length connecting the Island of Luzon with Formosa would immediately bring the Great Northern Telegraph system, whose land lines cross Siberia to Vladivostok into connection with the Pacific cable, and thus secure an independent connection between the Philippine Islands, Japan and the Asiatic mainland—now a monopoly of the Eastern Telegraph Company—as well as open to Japan the benefits of the new direct cable route to America and Europe with its consequent reflected importance to the United States.

It is believed that there is no service which is more necessary in peace or war, for the benefits of commerce, diplomacy and sea power ; for the security of coasts against sudden attack, and the ravages of approaching storms ; for protection against the visitation of infectious diseases, and the full realization of the influence of the Isthmian Canal, than a trans-Pacific cable under the impartial and exclusive control of the Government of the United States.

WARSHIPS AND SEACOAST BATTERIES. OPERATIONS OF THE AMERICAN SQUADRON AT SANTIAGO DE CUBA.

Translated from the *Revue d' Artillerie* for April, 1899.

"A gun on land is worth a ship at sea."

The war between the United States and Spain, which was brought about by the Cuban insurrection, has furnished valuable lessons for future warfare. It fully demonstrated that it is of paramount importance to possess well manufactured, well supplied, and well served matériel if the artillery is to be made a preponderant element of success.

The principal works consulted for this article are *Combates y Capitulación de Santiago de Cuba* by José Müller y Tejeiro, lieutenant of the navy and second in command of the marine of the province; and the March number of *Streffleurs Oesterreichische Militärische Zeitschrift.*

DEFENSIVE RESOURCES OF SANTIAGO.

Santiago, capital of one of the Cuban provinces, is a city of about 45,000 inhabitants and is situated at the end of a very safe harbor. At about four miles distance from the city is a very narrow entrance to the bay, which is guarded by the heights of the *Morro* on the east, and by those of the *Socapa* on the west. These heights, the average altitude of which is about 65 meters, are very difficult of access by land, and on the seaside terminate in very abrupt, steep rocks.

The entrance to the bay is thus provided with natural defenses; the heights of the *Morro* on the right, the Socapa on the left, and facing the entrance are those of the Punta Gorda. The last is an excellent position from which the channel can be swept and the vessels of the enemy can be held under its fire for at least twenty minutes, while engaged in the narrow entrance.

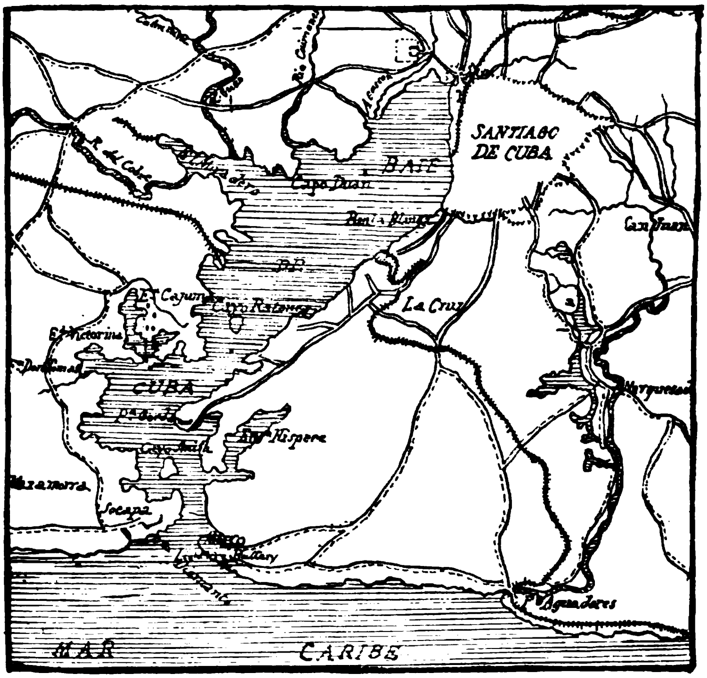
Moreover, nothing could be more easy than the defense of the torpedo lines by rapid fire guns, mounted on the western coast of the bay and under excellent cover obtainable there.

Preparation for Defense.

At the outbreak of hostilities the position of Santiago was not in a state of defense. A number of projects had been planned, but none had been approved and so nothing further had been done.

At *Punta Morillo* (the western point of the *Morro*) there was a fortified castle with massive walls which might have been a good fortress in its day, but at present it is only a very fine target for the fire of a fleet.

Upon the *Socapa* the ancient batteries of La Estrella and Santa Catalina lay in ruins.



For its defense, the city of Santiago possessed but a single battery, which had been used solely for firing salutes to visiting warships. One of the first acts of the Council of Defense of the place was to have this battery transported outside the existing works to defiladed positions. Four batteries were organized; we will designate them as those of the *Morro*, the *Socapa*, *Punta Gorda*, and *La Estrella*. The fourth having played no rôle in the defense, only the three first will be described in this article.

The Morro Battery.

A lighthouse is situated at about 200 meters to the east of the old fort. It is about 100 meters to the east of this lighthouse that the new battery was constructed at an altitude of 63 meters.

The main works were formed by wooden boxes filled with concrete and forming merlons, the distance between the axes of which was 6 meters. The spaces between the casks were filled with concrete or sand. The parapet was strengthened with sandbags upon its exterior surface.

At about 10 meters in rear of the battery a ditch was dug for the protection of the men while serving the guns. It was 1.50 meters deep, 0.60 meters wide, was parallel to the breastwork, and zigzag works establishing communications joined it to the gun emplacements.

On the 28th of May, this battery was armed with five 16 cm. muzzle-loading guns. These guns were of bronze and of very ancient construction, and had been remodeled toward the middle of the century according to the *La Hitte* system.

According to *Streffleurs Oesterreichische Militarische Zeitschrift*, certain of the guns at Santiago bore the dates 1688, 1718, and 1769, and perhaps had previously served against the coast pirates and buccaneers.

The projectiles were studded and had a hemispherical head. They were piled up in the open air near the right piece. The fuze holes were stopped up with woolen plugs. After the surrender no fuzes could be found. The charges were manufactured in the battery.

The iron carriages, mounted on front pintle chassis, were supplied with rather primitive friction brakes, and with a graduated disk, fitted with an index, for indirect aiming. They could turn on circular rails fastened in the concrete; but the implements regulating the lateral displacement were lacking.

The battery of the *Morro* was reinforced on the 25th of June by a section of two 21 cm. muzzle-loading howitzers which were placed in position to the east of the principal battery and separated from the latter by an interval somewhat greater than the interaxial distance.

For the protection of the gunners a ditch of 16 meters square and 1 meter deep had been dug.

The Socapa Battery.

This battery was situated 400 meters to the west of the outlet of the bay, upon the commanding point of the heights. Its dispositions were analogous to, although a little better than, those of the *Morro*..

The armament consisted of three 21 cm. muzzle loading howitzers and two 16 cm. guns of the Hontoria type, mounted upon naval central-pivot carriages. The two latter guns were of recent model but were not rapid fire ones. They could each be fired in from two to three minutes.

The section of Hontoria guns was separated from the howitzers by a wide traverse. The naval carriages had a shield 3 cm. in thickness. There were no casks filled with concrete, forming merlons, placed in this part of the battery.

About twenty meters in rear of the battery was the ammunition magazine which was a sort of hut, slightly sunken, covered with corrugated iron, and protected from attack from the sea by a small earthen levee. After the surrender quite a number of 16 cm. projectiles were found in this magazine as were also charges and powder cases.

To the east of the battery, on the most prominent part of the Socapa, one 57 mm. Nordenfeldt, four 37 mm. Hotchkiss guns and one 11 cm. Nordenfeldt machine gun, had been placed for the special protection of submarine torpedoes.

Battery of Punta Gorda.

This battery was situated at 2000 meters in rear of and enfiladed the entrance. Its armament consisted of four breechloading guns; two 9 cm. Krupp guns, two 15 cm. Mata howitzers, and two 16 cm. naval Hontoria guns.

The cruiser *Reina Mercedes*. The defense was strongly reinforced by the armament of the *Reina Mercedes* which had been incapacitated in the Bay of Santiago, on account of the bad condition of her boilers. This vessel furnished the four 16 cm. Hontoria guns, two of which had been placed on the Socapa, and two on the Punta Gorda, with the view of attacking the hostile ships directly.

The small caliber guns, intended to defend the torpedo lines and prevent their being approached by small vessels, had also been taken from the *Reina Mercedes.*

FORCES OF THE ATTACK.

The number of the American war vessels which appeared before Santiago is very large. In the following table are given the specifications of only those vessels which have taken part in the principal attacks, leaving out those which might have taken part in some of the operations of the blockade.

Armament of the American Vessels. Vessels of the same class do not always have the same armament, but the difference is so slight that we will describe one as a type.

The armament of the *Iowa* (figure b) consists of:

Names of Vessels.	Displacement.	Length on Waterline.	Breadth on Waterline.	Draught of Water.	Speed per Hour.	Thickness of Armor.		Number of Guns.			Effective Strength of the Crew.	Year when Launched.
						Belt.	Deck.	Big Caliber, 20 cm. and more.	Medium Caliber, 10 to 20 cm.	Light Artillery.		
Armored Ships.	tons.	m.	m.	m.	knots.	mm.	mm.					
Iowa	11,340	110	22	8.1	17	353†	62	12	6	30	490	1896
Indiana	10,300	106	21	8.2	15	457	62	12	4	32	460	1893
Massachusetts . .	10,300	106	21	8.2	16	457	62	12	4	32	460	1893
Oregon	10,300	106	21	8.2	16	457	62	12	4	32	460	1893
Texas	6,400	92	20	7.4	17	305	51	2	6	24	392	1892
Armored Cruisers.												
Brooklyn	9,215	122	20	7.9	21	76	152	8	12	22	561	1895
New York	8,200	116	20	8.1	21	102	152	6	12	16	522	1891
Amazonas * . . .	3,500	108	15		22							
Protected Cruiser.												
Minneapolis . . .	7,375	126	18	7.8	23		102	1	10	19	456	1893

* Bought from Brazil shortly before the declaration of war.

† Harveyized steel.

Four 12-inch (305 mm.) guns placed in pairs with parallel axes in barbettes.

Eight 8-inch (203 mm.) guns placed in pairs in four barbettes at angles of the superstructure.

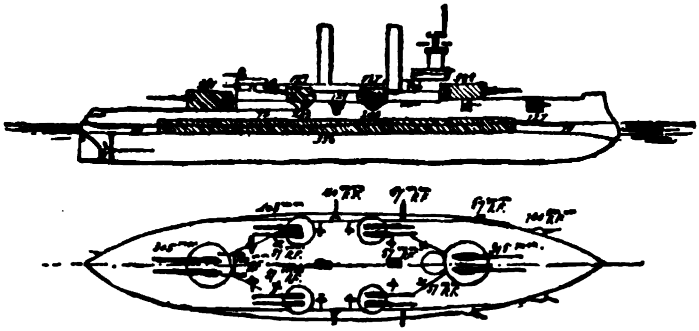


Fig b. Iowa.

Six 4-inch (101 mm.), twenty 57 mm., six 37 mm., guns, all rapid fire guns.

Four Gatling guns.

The field of fire of the 12-inch guns is 270 degrees, and their height above the water is of 7.60 meters forward and 5.50 meters aft.

The field of fire of the 8-inch guns is 180 degrees; the axes are 7.60 meters above the water.

The armored cruiser *Brooklyn* (figure c) is armed with;

Eight 8-inch (203 mm.) guns, placed in four barbette towers at the vertices of a lozenge.

Twelve 5-inch (127 mm.) rapid fire guns.

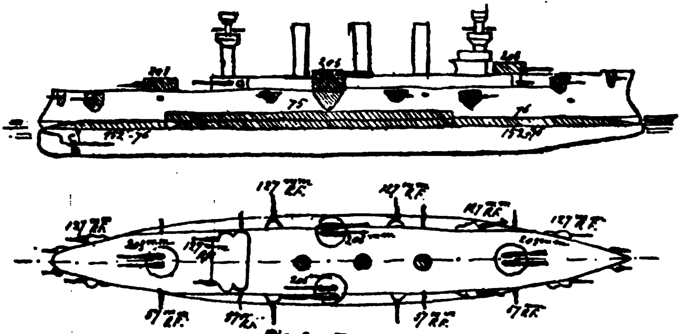


Fig. c Brooklyn.

Twelve 57 mm. and four 37 mm. rapid fire guns, and four Gatling machine guns.

The field of fire of the 8-inch (203 mm.) guns is at least 180 degrees and the axes are 10 meters above the water.

Lastly, the protected cruiser *Minneapolis* is armed with:

One 8-inch (203 mm.) gun.

Two 6-inch (152 mm.) and eight 4-inch (127 mm.) rapid fire guns.

Twelve 57 mm., four 37 mm. rapid fire guns.

Four Gatling machine guns.

Ballistic data. The larger caliber artillery of these vessels is composed of the 13-inch (330 mm.) 12-inch (305 mm.) and 8-inch (203 mm.) guns. The cruisers *Indiana, Massachusetts* and *Oregon* have each four 13-inch (330 mm.) guns instead of the 12-inch (305 mm.) guns of the *Iowa* and the *Texas*. The following table gives more numerical data showing the power of those guns:

TABLE.

Nature of the Data.		8-inch Guns (203 mm.).		12-inch Guns. (305 mm.)	13-inch Guns. (330 mm.)
		M. III.	M. IV.		
Weight.	kg.	13,230	15,300	45,585	61.500
Total Length.	m.	7.75	8.75	11.22	12.192
	cal.	35	40	36	36.9
Capacity of the Chamber.	dcs.	52.04	52.04	197.34	—
Weight of the Charge.	kg.	34	34	192.9	249
Weight of the Projectile.	kg.	113.40	113.40	335.550	499
Initial Velocity.	m.	634.4	655.7	640.5	640

Use of the Vesuvius. The Vesuvins is a vessel of 900 tons displacement, long, narrow, and low. She is armed with 38 cm. pneumatic guns, and firing shells or projectiles weighing 680 kilograms which contain 272 kilograms of a high explosive.

On account of its short range (about 2 miles) and limited field of fire, the Vesuvius cannot engage another vessel in battle; but the Americans deemed it possible to utilize her advantageously against the works of Santiago. She appeared in the Cuban waters on June 15th and remained until the 26th.

EFFECTS OF FIRE.

History of events.—The American vessels made their first demonstration before Santiago on May 18th and they fired 160 shots to which the battery of the Punta Gorda replied.

From May 15th until June 5th, the bombardment was not of great importance, but on June 6th at 8.30 a. m. the American squadron, composed of the warships formed into two divisions, opened a most violent fire which lasted until 11.30 with but two intervals of 15 minutes each.

The eastern division bombarded the Morro and the Aguadores; the other the Socapa and the Mazamorra.

The ammunition expended on that day is estimated to be 8,000 projectiles by the Spaniards. This number is plausible when it is taken into consideration that there were about 100 guns in action and that the fire lasted 175 minutes, the shots averaging one per gun every two minutes. In reply there were but 47 shots fired from the high battery of the Socapa; one of the causes of this small number of projectiles fired was, it appears, the density of the smoke enveloping the vessels.

On the 14th, 16th, and 18th of June there was some bombardment by the Americans. The 22d of June was the day on which the expeditionary corps disembarked and the *Brooklyn*, the *Iowa*, and the *Texas* bombarded the Morro and the Socapa which replied in due form. The battery of Punta Gorda fired five shots. On the 2d of July, simutaneously with the attack by land upon the defenses of the city, a further naval bombardment took place.

Results of the firing from the works. It is evident that the cannoneers of the coast batteries of Santiago could not pretend to obtain serious results with their "Bombards of the Middle Ages."

The fact is still further proven when it is known that, upon taking possession of the Morro the Americans found a certain number of howitzers still charged, and when "one of these was fired at a high angle it gave the astounding range of about 730 meters."

But the Morro and the Socapa batteries each fired a shot that told.

At the Socapa battery a projectile from one of the 16 cm. naval guns was successful in striking the *Texas* on the portside, some 20 feet in rear of the prow, traversed the stanchion, exploded between decks, and killed one man and wounded six.

From the Morro a shot from a 21 cm. howitzer struck the *Iowa* during a night engagement. The battery being illuminated by an American searchlight, fired; but it was the *Iowa*, hidden in darkness, that was struck and not the ship that used the light. The shell traversed the wall and exploded in the officers' mess, no one was injured.

Effects of the fire of American vessels. In spite of the powerful means at the disposition of the attacking forces, the effects of their fire were insignificant.

The Morro castle, a target clearly outlined against the sky, was somewhat damaged, as were also the buildings situated between the lighthouse and the fort. The sheets of corrugated iron, some 25 mm. thick, which formed part of the constructing material of the lighthouse, were pierced by several small caliber projectiles, among them even some 15 cm. howitzer shells. The sheets on the opposite side were entirely torn up by the explosion of the projectiles.

On the Morro battery, the 16 cm. gun on the extreme left was overthrown by a projectile, but no other damage was caused, with the exception of a few bags of sand, which were torn to shreds.

A 20 cm. projectile fired without a fuze was found in rear of the battery.

It is noticeable, generally speaking, that the fuzes of the American projectiles were very unsatisfactory. This fact was also noticed in the bombardment of San Juan and also during the naval battle of Cavite.

The Socapa battery seemed to have been the principal target in the bombardment. The Americans probably supposed that its armament was more to be feared, which, in fact, was also the case. On the 16th of June a large caliber shell (32 cm. according to Lieutenant José Müller y Tejeiro) literally buried under ruins one of the two Hontoria 16 cm. guns. But that was dug out during the night and could be fired on the following day. A 15 cm. projectile pierced the shield of the left 16 cm. Hontoria gun and slightly damaged the mount, but did not dismount the piece or render it unserviceable.

A small caliber projectile also struck the upper part of the left flask of one of the howitzer carriages, but did not cause any serious damage to the latter. Lastly the epaulment and the bags of sand got a few shots, but the wooden barracks serving for the storage of ammunition, had not been touched.

Several times during the night the *Vesuvius* fired two or three projectiles against the batteries at the entrance of the harbor. She was in the habit of approaching close to the coast accompanied by another vessel, usually an armored cruiser, charged with her protection. "When one of these bombs," says Lieutenant José Müller y Tejeiro, "falls in the vicinity of a battery, the latter is sure to be entirely destroyed, for one must experience the effects of one of these projectiles to understand them. Fortunately the firing of these guns lacks precision in range and in direction. A projectile striking the northern slope of the Socapa cut down the trees to the right and left for a space of about 20 meters; it looked as if a road had been opened. Another made a rather shallow excavation, but wide enough to contain 20 horses."

LOSSES SUFFERED BY THE PERSONNEL OF THE FORTIFICATIONS.

The following table gives the detailed data as to the losses suffered per day by the personnel of the defense.

OBSERVATIONS AND CONCLUSIONS.

The following fact must be remembered. In spite of the several days' bombardment and the enormous amount of ammunition expended, the American fleet had not only failed to destroy the batteries of the Morro and the Socapa, but the damage caused to these had been very slight.

These results are much more remarkable when the difference between the conditions of the two adversaries was so marked. The Spanish coast batteries were in reality only emergency works, armed mostly with ancient pieces, lacking in everything, and served by improvised gunners*; while the American war ships possessed modern artillery, well supplied, well served; and many in number.

The following reasons have been put forward in order to justify the meagre results obtained by the American naval artillery:

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* The armament of these works consisted as already mentioned of 18 guns, 14 of which were muzzle loading. The number of gunners was 79.

TABLE.

Batteries	Date	Killed*	Wounded		Total
			Officers	Privates	
Morro	June 6	2	5	25	32
	" 16	1	1	10	12
	" 21	–	–	3	3
	" 26	–	–	8	8
	July 2	1	1	31	33
Socapa	June 6	–	–	8	8
	" 14	–	1	6	7
	" 16	2	1	6	9
	" 22	–	1	–	1
Other works	"	1	–	2	3
Total	—	7	10	99	116

* Not a single officer has been killed.

1. The fuzes of the American projectiles worked unsatisfactorily; explosions took place prematurely and some even in the bore; a certain number of projectiles did not explode at the point of fall.

2. Blinded by the thick cloud of smoke, due to the use of black powder the Americans were often obliged to slacken or even cease fire, and were always impeded in making observations of the effects of the shots.

In spite of the value of these statements, and although the fire was sometimes divided between the coast batteries and Cervera's fleet (the Americans are said to have been informed of the position of the squadron and especially of that of the *Reina Mercedes* by their Cuban allies), the number of the shots that told, is nevertheless out of all proportion when compared to those directed against them.

The papers had more than once declared that the Morro and the Socapa "had been silenced."

By examining the results we come to the conclusion that the Spaniards stopped firing only because they were conscious of their weakness and of the inefficiency of their fire.

It may thus be said that the bombardment of the works of Santiago has been a firing school rich in lessons for the American naval gunners.

* * * * * * *

It is interesting to find out what might have been the mode of action of large caliber artillery of the American vessels against the batteries of the Spanish coast at an altitude of some 63 meters.

For a range of about 2,000 yards (about 1800 meters) the distance from which the bombardment of June 6th* took place, the protection of the parapets was very efficient as shown by the following sketch:

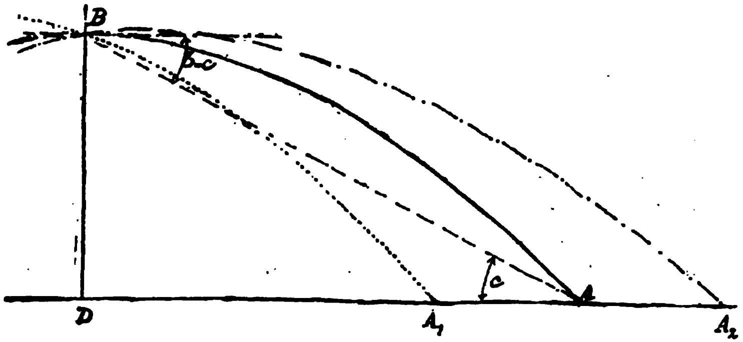

Fig. 2.

Taking into consideration the angle of sight *c* we find that the height of the parapet is approximately equal to the maximum ordinate *BD* of the trajectory AB, corresponding to the firing data, for the American 8-inch and 12-inch guns. Thus, in this particular case in which the target is at the summit of the trajectory † and the angle of incidence being zero, one could not count upon grazing and carrying off the crest, and hitting materiel or personnel but by a chance shot.

At shorter distances, *i. e.* when the protecting crest is placed between the maximum ordinate of the trajectory AB and the vessel A, the angle of incidence is negative and the firing of the naval guns becomes less and less efficient. At long ranges the projectile strikes at more favorable angles, but the shot may lose some of its precision.

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* Admiral Sampson has given in his despatches, relating to this bombardment, the range of 2,000 yards.

† In order to render the above figure more clear, the scale of heights has been considerably increased.

To sum up, the altitude of 63 meters considerably increased the protection of the parapet under battle conditions. By this fact the unsatisfactory results obtained by the firing of the American artillery may be explained.

The Spaniards were well inspired, when installing their improvised batteries, to avoid traverses or piled up earth, which by forming parados, increase so much the effect of the projectiles on the personnel of the batteries. But they do not seem to have taken sufficient care to conceal these batteries (the geometrical outlines of which were too prominent) and to attract the enemy's fire by sham batteries, losing sight of the fact that the principal defense of coast batteries in the presence of men of war which are always clearly seen, lies in their difficulty to be seen.

* * * * * * *

"It has been once more proved by experience," says the author of the article in *Streffleurs Zeitschrift*, "that coast batteries have little to fear from war vessels."

"It is unpardonable that the squadron," said the American officers detailed to take possession of the old guns of the Morro battery, "has not destroyed the city and its defenses in so many days." (Combates y Capitulación de Santiago de Cuba by José Müller y Tejeiro).

It may be of some interest to indicate the ideas current in England in regard to the risk incurred by the two sides in an engagement between a naval force and coast fortifications.

Among other articles upon this subject which have appeared in the *Proceedings of the Royal Artillery Institution* we will mention only one, signed by Major R. P. Johnson and published in July 1893.

The general tendencies of this article are characterized by its motto. It is the old French proverb: "Le cout fait perdre le gout" (The cost makes one lose the taste). The author invites the marines in charge of the defense of coast batteries to meditate upon the above. He also quotes the words of Admiral Selwyn: "Naval officers must consider a fort as a thing to be avoided."

The English seem also to have adopted an ancient French maxim and apply it to the present times. In the Naval Annual for 1898 Mr. J. R. Thursfield ends as follows the chapter treating on naval maneuvers:

"A gun on land is worth a vessel at sea." When a narrow and sinious estuary is to be defended, guns, not necessarily large caliber ones, but well placed and well served, are worth an "armada" of vessels which do not like the open seas (alusion to a squadron which stays near the coast in order to defend it). But at present, as at the time of Armada, the best way of preventing attacks against the coast, is to go and seek the hostile fleet upon the sea."

* * * * * * *

To close this article the opinion of two French military authorities on the attack of coast batteries by warships should be given.

Admiral Fournier in his work "La Flotte nécessaire, ses avantages, stratégigues, tactiques, et économiques," published in 1896, speaks as follows :

"In an engagement between vessels and concrete coast defence, armed with a powerful modern artillery, it is not impossible, in fact, to weigh in the same balance the risks encurred by both sides. Such contest may be considered when it is necessitated for the purpose of adding, from the sea, by bombardment at long range, the principal attack made by troops on land which should end by the taking possession and the military occupation of the obstacle. But undertaken singly, such an engagement has no other termination than the retreat of the attacking party. For, however great may be the relative success of the bombarding party, it will be forced to retreat when it finds that, without having obtained any reasonable advantages, it is weakened by the losses and damages caused by the answering fire of the enemy, by the expenditure of the greater part of its ammunition, and exposed also—should the action be prolonged—to falling into the hands of a hostile naval force coming to the rescue of the defense, or in danger of a storm which may overtake it on its return and inundate it through its open leaks to such an extent as to even threaten it with shipwreck.

* * * * * * *

To sum up, the predominant object of our naval force must, first of all, be to fight the enemy afloat everywhere and under all favorable conditions where he may be encountered, and thus remain master of the sea, after having completely reduced the enemy. But as long as this result is not attained, *it is imprudent to expose our vessels against coast fortifications in fruitless engagements, more weaking and demoralizing in general to the assailants from the sea than the defenders on land.*"

The author of an article published in 1894 in the *Memorial de l'Artillerie de la Marine* expresses his opinion as follows:

"The great power of the guns, the precision of their fire, the use of apparatus giving the range, direction, and speed of the target, the use of high explosives in the shells, the substitution of smokeless powder for the black powders in the charge, the new defensive organization of the works, the torpedo-boats, the stationary torpedoes, and the electric lights, have considerably increased the defensive value of land batteries; while the vessels, representing the offensive power, although armed with more powerful guns, protected by more resisting armor, etc., have nevertheless kept, with a vastly increased cost of expenditure, a fragility so great that they may be put out of action by a single projectile. This considerable cost price constitutes another cause of inferiority for the great risk run by the vessel in its offensive action so far outweigh the results attained.

* * * * * * *

Concerning the naval operations examined in the present study we see that the defensive power has not only increased more than the offensive one, but that such offensive operations have lost almost all their value.

We often hear of the damages caused to coasts by the squadron artillery; these are generally speaking, fancies that do not merit any attention. It is only possible to cause some slight annoyance to the population of the coast, and the European nations do not take up arms at present for such meager results.

We share the opinion of those who deem the establishment of too numerous batteries on the coast to be but a useless expense. They must be established very sparingly.

The coast of a great nation is at present defended by others means; the batteries exist only for the purpose of preventing a *coup de main* upon some important city or to protect an arsenal, the preservation of which is of importance to the national defense,"

[Translated by Lieutenant WINFIELD S. OVERTON, 7th U. S. Artillery.]

PROFESSIONAL NOTES.

TACTICS.

The War—The Artillery at Colenso.

By C. Holmes Wilson, Lieutenant 73rd Battery R.A.,
2nd Infantry Division, Natal.

Never was a more unique artillery contest commenced than that begun on the morning of the 15th December at Colenso. The Boer position was practically impregnable. Covered by the Tugela, intersected by intrenchments and with every approach commanded by a heavy gun, it was a fortress in itself, and would have required a siege-train to besiege it instead of the 15-pounders which formed part of our field force. The part played by the artillery was consequently peculiar. For the first time in modern warfare we had field guns opposed to a civilized foe who was fighting behind intrenchments and had his artillery under cover, and for the first time in the records of our regiment our field artillery found themselves outclassed by the weight of metal that they had opposed to them. It would be idle to deny it and foolish not to face it, but the Boer artillery had not only the choice of the positions but the best of the engagement. One thing alone preserved that portion of our field artillery that escaped unscathed and that was the defective quality of the enemy's shell. If it had not been for this our guns would have been driven off the field and the crisis that had been foreshadowed by the earlier events of the campaign would have been confirmed by a lesson that would have led to even greater losses than those that we unfortunately sustained.

The situation at Colenso before the battle was undoubtedly misleading. For two days the place had been bombarded by the naval guns without any signs of life being seen within the trenches. It was consequently not altogether unreasonable to suppose that the position had been deserted. The Boers had not been credited with the *sang-froid* and tactical diplomacy which the issue of the contest and the behavior under fire eventually proved them to possess. It was believed that if they were in Colenso they could not have resisted the temptation of replying to our fire, particularly as portions of our camp must have been within effective shooting distance of their long-range guns. The Boer has however developed tactical and strategical qualities which he did not formerly possess and for which nobody would have given him credit before the commencement of the campaign.

Disaster had been predicted to the burgher's forces if they used artillery with their commandoes, instead of this however experience has taught us that they are doing more with their artillery than we can do with our own. For instance take the present case. It was impossible to prepare Colenso for the infantry attack by a preliminary bombardment because the position of the enemy's guns remained undisclosed until the infantry advance had actually commenced. Yet when the Boer artillery did begin to fire it was evident that they commanded every approach to the position and that many of their guns were out of range and out of reach of our own artillery who had to manœuver in the open plain beneath their well-directed fire. The problem consequently becomes a question of whether field guns can be maneuvered in the open against guns of position under cover which they probably cannot touch and almost certainly cannot hurt. The large target afforded by a field battery in line at full interval makes shooting a matter of simplicity to guns such as the Boers had placed in position behind Colenso. The answer to the query is however of more than passing importance to us now, for if field artillery has to face powerful guns in position under cover, a new development in the future tactics of the arm may not unreasonably be looked upon as unavoidable. What then are the prospects of a repetition of the tactical situation that led to the encounter at Colenso? The principles that have governed the employment of our artillery in the field have so far rarely been dictated by ideas that have favored the extensive use of cover. Yet every improvement in artillery material has pointed to the probability of such a development becoming a necessity. With accurate weapons the tendency to make use of cover must increase, and if powerful guns can be employed where an extensive field of fire can be obtained it is evident that provision will have to be made for the protection of the assailants in the earlier stages of the fight. One force will generally have to act on the defensive and if this force can put heavy artillery into position their assailants will of necessity have to bring up equally powerful guns to displace them. It is consequently possible that we are on the eve of a new development in the employment of artillery that may modify many hitherto well-accepted tactical ideas. It has however been urged that such a condition of affairs as that which at present exists in South Africa, could not have occured in any other country in the world except Natal and it is perhaps better to consider this assertion before proceeding to discuss the question any further.

Natal is undoubtedly an open country. The broad tracts of open veldt, which in times of peace afford a fertile grazing-ground for the flocks of the colonists who live by farming, are often exposed to view for miles from the summit of some isolated ridge or stone-crested kopje. Immediately opposite Colenso the veldt slopes in sweeping folds towards the valley of the Tugela which winds in a sunken bed below the higher hills of the northern bank. At the time of the battle the town itself looked nothing more than a collection of a few tin-roofed houses faced by a road and railway bridge across the river. In rear however it was overshadowed and outflanked by a formidible ridge of heights which ran in a cresent round the town. Along these the Boers had placed their guns and from them they could easily command the approaches to the opposite bank. Consequently when in the dusky dawn of a December morning our forces marched to the attack they did so at a decisive disadvantage to themselves, for as far as the ground they had to cross can be considered, every kopje and corner of it was commanded by the enemy's heavy guns from the heights behind Colenso. On the left there was no cover, on the right there was less and in the centre none. Yet over these open plains battalion after battalion moved to the attack of an enemy who could not be seen. The Boers are masters of the art of taking cover, scarcely a man who fought in the fight of the 15th December can say with truth that he saw a Boer, while as for their artillery we had no idea where it was until the battle had begun. Now if it is possible to conceal artillery like this what is the use of putting field batteries in the open to oppose it? At Colenso many of the enemy's guns were out of range of our 15-pounders whilst the 15-pounders were within easy reach of them! Indeed all their batteries were beyond the reach of time-shrapnel and those that were within range could only be reached by percussion shell. Consequently our field batteries were practically a failure and if it had not been for the naval guns a large proportion of the Boer artillery would have escaped unscathed. The reason that our field batteries were able to keep in the field as long as they did was principally due to the fact that very few of the enemy's shrapnel burst. The position of our artillery, particularly on the left, was decidedly peculiar. They could not advance because their road was barred by the river which it would have been impossible to cross and they could not retire because they would then have been beyond the effective range of even percussion shell. Yet whatever they did or wherever they went they could not get away from the enemy's indefatigable long-range gun until it was eventually silenced by some of the naval guns. It was prepared for them when they advanced, it pounded them when they halted and pursued them when they retired. What happened on the left was repeated on the right with even greater force and if it had not been for the Naval Brigade the Boers would not have suffered much from our artillery fire. Of the artillery with the three columns, the batteries with the centre column fared the worst though there is perhaps less to learn from their destruction than may be drawn from the smaller losses of those with the other two. Rushed too far to the front at an early stage of the engagement the guns with the centre column were annihilated before they could establish their position and the part they played can only be pointed to as a further proof of the well-known maxim that artillery cannot compete with infantry at ranges of 800 yards.

Under these conditions it is impossible to condemn the use of heavy artilllery with an army in the field. It is all very well to say that it is not mobile and to add that if we had crossed the river at Colenso the Boers would have lost their guns. I do not think that such would have been the case. A long-range gun can be put further back than an ordinary field-piece, and it can, consequently, be more easily withdrawn. Heavy guns of course can never take the place of field artillery, but if heavy guns can be employed in Europe as they have been used in Natal some alteration in the artillery armament of an army corps is urgently required. A position like Colenso can be prepared, but the tendency of the day is to use all the cover that can be procured, and if long-range guns can be concealed before the commencement of an action in a position which cannot be turned, they will only be displaced by the similar employment of equally powerful pieces. Now it is more than possible that for any general engagement such a position could be procured. Large armies will not stand to fight in an open plain, and there are many places in England even from which an extensive view can be obtained. Take for instance the famous ridge at Dorking or the Downs by Arundel. Long-range guns could see and shoot for miles from the summit of either of these positions. Or take another case, if the Boers had spent the summer on Salisbury Plain they would probably have given us a lesson in artillery tactics by placing a heavy gun on top of Sidbury Camp from which the country could have been commanded for miles. These are however only suggestions as to what might be done, there will still, of course, be always plenty of work for mobile batteries to do, but to think that mobility, as the term has been applied to artillery, will lead to nothing but the use of field-pieces like the 15-pounder in the future seems absurd. At Colenso half the enemy's guns were beyond the reach of our effective shrapnel and the other half were out of range. A country may not always be adapted to the use of long-range guns, but there may be places in it from which they could be used, and if the guns are not forthcoming when these positions are reached their absence may lead to difficulties such as those that have had to be faced in Natal. At home we have excellent material in the Volunteer Artillery for the foundation of such a force. If the Volunteer position batteries were re-armed they could easily fulfill the *rôle* without any special extra training.

—*The United Service Magazine*, February, 1900.

ARTILLERY MATERIAL.

War Material.

Armor has continued to exhibit increased powers of resistance, and has enabled defense to gain on attack in battleships. Previous to the successful face-hardening and cementation of steel plates, steel stood to wrought iron with a figure of merit of 1¼; that is to say, 1-inch of steel was equal to 1¼ of wrought iron. Harveyed armor has proved itself equal to at least 2 of wrought iron in thick armor, and more than that in 6-inch plates—perhaps 2¼. Krupp process armor has even approached 2.8 or 2.9, but the same plate was perforated by a capped shot with a figure of merit of 2.3, which indicates a possibility of an uncapped shot doing the same by striking so directly as not to break its point. Uncapped shot in published accounts, however, have never actually perforated with such a factor, and we may call Krupp process armor generally equal to from 2½ to 3 times its thickness of wrought iron for thin and even thick plates, unless caps are used; and the greater power of capped shot needs to be established at ordinary fighting angles of impact before it can be treated as thoroughly practical, though we believe that the cap is adopted in Russia and in America. The great toughness of the Krupp armor, which appears to be maintained in a remarkable degree in thick plates, is no doubt partly due to the presence of nickel, and partly to the method of treatment, and the hardness to cementation, and the chromium and quenching treatment, so that Hadfield may be pardoned when his projectiles are defeated by such plates, if he exclaims, like Simon de Montfort when he met his doom at Evesham, "They come on in wise fashion, but it was from me they learnt it," for Hadfield took the lead long ago in exhibiting the powers of chromium. The great resisting power of armor with cemented and treated face has affected the design of warships and cruisers, but we confess to some surprise that more ships of the *Garibaldi* class have not been built — that is, a vessel covered practically all over with 6-inch hard-faced armor. Such a vessel may defy nearly all shell attack, and in these days of high explosives that means much. Those who read the lesson of Santiago carefully can, we believe, see how awkwardly placed the *Brooklyn* might have been had the *Colon* come to close action with her. We look upon it, however, as a mere question of time before this class comes in largely. The type of battleship brought in by Sir W. White continues to be more closely copied; for example, the Japanese *Mikasa*, building at Barrow, is simply a *Formidable* modified and developed slightly further in certain directions, as by means of 200 tons additional displacement. The newest United States designs for the *New Jersey* class is the same, with the exception of certain features.

In heavy ordnance there is little to record; indeed the interest in ordnance has centered almost wholly on medium and light guns. The introduction of hard-faced plates of medium thickness to protect the quick-firing batteries of foreign battleships calls for increase in power of quick-firing guns. For example, the battleship *Retwizan* building at Cramps yard for Russia, has 5-inch Krupp process plates in front of her quick-firing batteries. We have given the account of the proof of these plates at Indian Head. The result is such as to show that this ship might defy the attack of our 6-inch quick-firing guns under ordinary service conditions, so that the 7-inch gun that has been long contemplated will be needed to speak to any purpose to the *Retwizan*. As we have said before, we admit that a projectile weighing 200 lb. is very inconvenient for quick handling, but what is the use of handling a shot quickly which fails to penetrate the object attacked? Slow and laborious success is better than handy and smart failure.

In dealing with the achievements of the year, it is impossible to omit the timely and masterly application of naval guns to the defence of Ladysmith—an achievement for which the nation is indebted to Captain Lambton and Captain Scott. The former grasped the situation, and we imagine, assumed considerable responsibility in the action he took. The latter showed the admirable quality of adapting means at his disposal to a new purpose in the simplest way. So far as we understand it, the story is as follows:—The 4.7 in. quick-firing gun is fixed on a pillar mounting on a ship's deck. It is a heavy piece, weighing about 42 cwt., and its quick fire, unaffected by recoil, depends on its rigid and well-designed mounting and deck attachment. Captain Scott fitted the mounting to a platform made of four lengths of piles bolted together to take the place of the deck, performing all the work necessary to enable those at Ladysmith to obtain what may be called the ship's gun position bodily, by simply setting those balks in cement. A second application of naval ordnance was made by fixing the mounting of the 12-pounder 12 cwt. quick-firing gun, with a muzzle velocity of 2210 ft. per second, on an improvised siege carriage roughly made by a baulk with wagon wheels fixed on it. The value of these pieces may be judged when it is remembered that our artillery force simply consisted of field battery and horse artillery 3 in. piecss, the former weighing 7 cwt. and the latter 6 cwt., firing shrapnel as their only shell. These guns are admirable for field work, but their power is far too little for siege work, the muzzle velocities of their projectiles being 1574 ft. and 1553 ft. per second, the heavier piece throwing a 15 lb. and the lighter a 12 lb. shell. The shrapnel fuse, however, only provides for 4100 yards range; hence a longer one is to be substituted. In the field not only has mobility to be considered, but also the fact that the gun is free instead of being fixed when in action, so that it is difficult to control its recoil in such a way as to enable the gun to retain its line of fire sufficiently to admit of quick fire. And this brings us to another artillery feature of the year, namely, the Clarke brake. The practical power of a field gun depends now on its brake as one necessary element, because a gun can be made strong enough and light enough to discharge a projectile with such energy that the gun and carriage recoil with unmanageable violence, unless controlled by a brake.

A good brake is required even to keep us from having to run the piece up to an unmanageable extent, and a much more complete brake to retain the direction of fire so nearly as to save the need of a relaying operation, which puts quick firing out of the question. The Clarke brake, which is not allowed to be published, though it has been imperfectly described in the *Revue d'Artillerie*, is now applied to our field guns so successfully that they are, we believe, equal to any quick-firing field guns in existence at present.

The question of high explosives in shells continues to attract attention. It makes little difference what particular kind is adopted, so long as the gun can be discharged without risk of the shell bursting in the bore. Wet guncotton, once the favourite, has long been superseded by melinite or lyddite, which are nearly, perhaps absolutely identical. Against thin armor, a shell containing high explosives acts with great violence, bursting into many fragments, enlarging the entrance hole, and generating gas, which in a confined space must drive men temporarily away. On the other hand, the action of powder is slower, and is carried farther into a ship, and is, we imagine, more likely to set wood on fire. In the field, common shells with high explosive or powder burst violently, and are necessary to reach men who are behind a parapet or cover, because shrapnel bullets depend on the onward velocity of the shell at the moment of bursting, the bullets all going forward in a shower, which is terrible when well directed on men in the open, but useless against those behind parapets. Against such, common shells have much more effect, because their fragments fly in all directions, and a high explosive, causing many more fragments than powder, is much more effectual. Shrapnel has been found far the best projectile for the ordinary work of field artillery, but the need of howitzers and pieces firing common shell has been terribly felt by us in South Africa, and our naval guns proved friends in need. Powerful 5-inch guns, firing common 50 pound shells filled with lyddite, have been now despatched to the seat of war on 40-pounder carriages; also 4.7-inch quick-fire guns on the carriages of the 6-inch howitzer. These will constitute powerful siege pieces, though the former will, we fear, have a troublesome recoil.

It seems necessary to give a few words to the threadbare controversy of Dum-dum bullets. The essence of it is that a very small bore nickel-sheathed bullet makes so small and clean a hole that, except in a vital part, it neither stops a man nor lays him up for long. It is natural, then, that men who find their bullets do not stop a charging enemy should nick their points with a knife. This causes them to spread out or even to break and fly on impact. A measure of setting up or spreading might give a sense of shock and stop a man without undue injury, but breaking up causes a cruel wound. It is difficult to deal with this question. The Peace Conference at the Hague decided against using bullets whose nickel sheath is tampered with, and both the Boers and ourselves issue ammunition with completely-sheathed points, but it can hardly be wondered at if men on service use their knives to slit or strip the points, making Dum-dum bullets of them. In fairness we must admit that the temptation besets the Boer most strongly, as he has been repeatedly charged home, and he carries no bayonet.

The war in South Africa gives continued opportunities for the development of the newest improvements in heliograph signals, the climate being well adapted for this work. Beleagured garrisons have thus communicated with relieving forces, who would thus not only learn of their condition, but arrange to act in concert against the enemy.

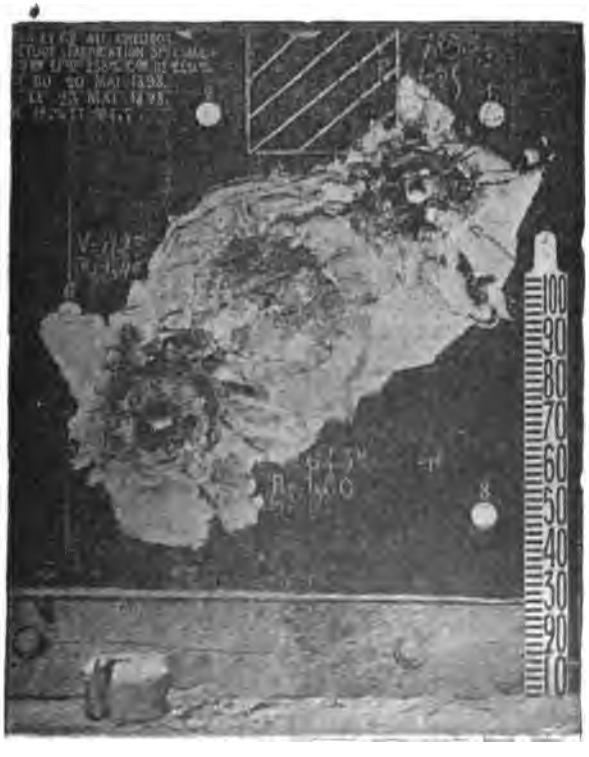
Balloons have been used for surveying the position and operations of the enemy; the locating of guns firing smokeless powder is a new need, which has been thus met to a certain extent. Wireless telegraphy makes it possible to despatch small balloons to drop projectiles at any desired point; the objections to this we have already noticed, and need not here repeat them.

One new form of military engineering the South African war is bringing in, namely, trenching on a new scale. Smokeless powder and magazine arms enable a trench to be held so easily against attack, that we may expect armies to trench in each other's front and endeavor to outflank each other, so that the ground will be seized and occupied as regularly as spaces were occupied in the ancient and honorable game of "oughts and crosses." Thus armies may stretch out their arms and try to surround each other, for the successful one might thus have less line to defend than is entailed by communications; and the encircled army has the desperate alternative of carrying the surrounding trenches, or of being starved into surrender. Short of this, outflanking and cutting communications by trenches will be a habitual feature of war.

—*The Engineer*, January 5, 1900.

Schneider Hard-Faced Armor.

We have received the result shown in the figure herewith, in answer to a request for information, from the Schneider Works, at Creusôt. The trial, it will be seen, took place last year. The result is remarkably good. The plate is 250 mm. (9.83 in.) thick. It is termed a special cemented plate. At was attacked, first, by one round from a 24 cm. (9.45 in.) gun, the projectile weighing 144 kilos. (317.5 lb.), striking with a velocity of 643 metres (2110 foot-seconds), and subsequently by two rounds from a 19.4 cm. (7.64 in.) gun, firing projectiles of the weight of 75 kilos. (165.3 lb.), with striking velocities of



785 and 812 metres (2576 and 2664 foot-seconds), which produced effects shown in the figure herewith. The first round has a calculated perforation of 21.3 in. of wrought iron, or 2.16 times the actual thickness of the plate; the last two rounds, 23.1 in. and 24.4 in. of wrought iron, the last being 2.49 times the thickness of the plate. This is a tremendously severe attack. The plate has entirely defeated it, but has cracked in thin cracks. The plate appears to be rather harder and less tough than those made on the Krupp process. If the scale shows centimetres, the projectiles must have spread and set up considerably.

Special Hard-Faced Schneider Plate.

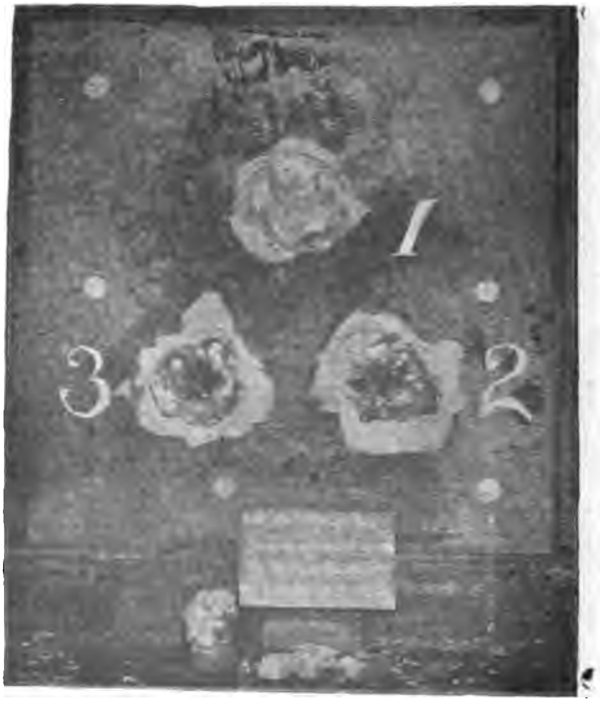
Thickness of the plate	250 mm. (9.843 in.)
Diameter of the projectiles: 1st shot	240 mm. (9.449 in.)
" " 2nd and 3d shots	194 mm. (7.638 in.)
Weight of the projectiles (240 mm.)	144 kilos. (317.465 lb.)
" " (194 mm.)	75 kilos. (165.347 lb.)
Nature of the projectiles	Chrome steel.
Striking velocity: 1st shot	643 m. (2110 f.s.)
" " 2nd shot	785 m. (2576 f.s.)
" " 3rd shot	812 m. (2664 f.s.)

Tested on the 20th and 23rd May, 1898.

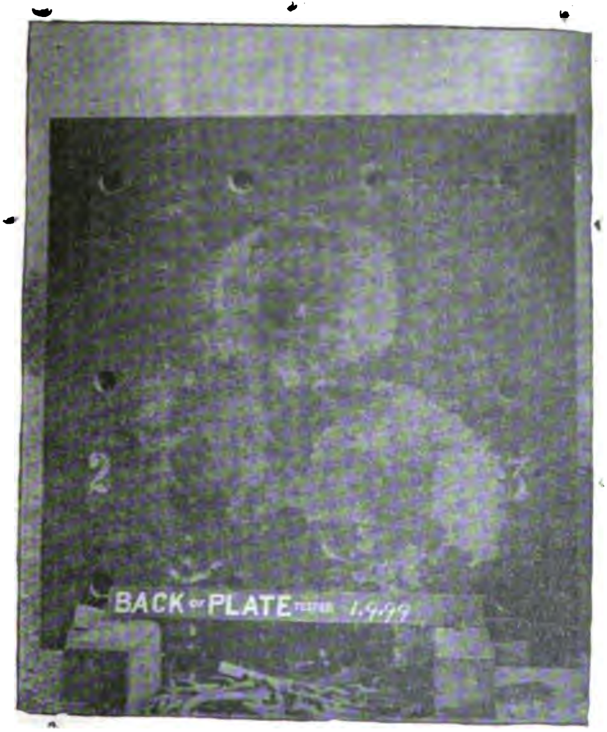
The Engineer, December 1, 1899.

Vickers' Armor for Japan.

In our issue of September 8th last we mentioned the trial of belt armor supplied by Vickers, Sons, and Maxim, Ltd., to the Japanese man-of-war



Shikishima, building at the Thames Ironworks. We are now able to give a photograph of the results of the trial. The plate was 8 ft. by 8 ft. by 8¼ in. It was termed a special nickel Harveyed plate, probably differing only in detail from the admirable Krupp process plates made by Vickers for our own Government. The attack consisted of three rounds with 9.2-inch armor-piercing steel Holtzer projectiles. Two rounds were delivered with a velocity of 1700 foot-seconds, and the third with 1800 foot-seconds velocity. Each projectile weighed about 380 pounds. By Tresidder's formula the penetration through wrought iron is 17.1-inch for the first two rounds, and 18.6-inch for the third, the tests implying a figure of merit of 1.95 and 2.13 respectively. As the projectiles, far from peforating, only penetrated to a depth of 3 inches and 3¼ inches, the plate had a much higher figure of merit; but we cannot say what it was. Our engravings show the front and back of the plates after the third round. The shots have evidently been thoroughly broken up. In the large official photograph a trace of white radiating lines is visible, and these always imply extreme disintergration, being the mark of Langridge skimming over the plate face. There are no cracks. As most of our readers are aware, the Japanese are having built for them very powerful ships of war, on the pattern of our heaviest. One, the *Mikase*, building at Barrow, appears to be more powerful than anything afloat.



—*The Engineer*, December 8, 1899.

British and Boer Guns—A Lesson from the South African War.

By Lieutenant Godfrey L. Carden, R.C.S.

There is a lesson to be learned from the war in South Africa which can well be taken home by every nation not supplied with field artillery the equal of the best. England, despite her great gun shops and enormous resources, has found herself outclassed from the start by the field-gun equipment of the Boers. The results, so far, have been checks, reverses, and defeats.

The superiority of the Boer field artillery over ihe English field-guns is not surprising, when it is known that the forces of the Transvaal are provided with Creusot and Krupp pieces. The only wonder is that England has been content to possess artillery weapons known to be inferior to the best guns on the Continent. We use the term "known" advisedly, since attention to this very fact has been called by prominent artillerists during the past two years. Reports from General White's forces state that the effective range for his field-guns did not exceed 4,000 yards. If General White is provided with the standard 3-inch Woolwich field-gun, which we understand is the case, the only surmise is that the range referred to shrapnel. For shell proper the Woolwich gun claims a range of 6,500 yards.

From late reports it is announced that a large number of the Boer field-guns consist of Creusot 14-pounder pieces of 2.96 caliber, employing muzzle velocities of 1,837 foot-seconds. The range claimed for these weapons is 8,744 yards. A peculiar feature of the 14-pounder is its narrowness of carriage track—3.56 feet—as compared with the standard 5 feet 2 inch gage English field carriage. The shrapnel shell of the 14-pounder contains 234 bullets. There is sufficient remaining velocity, it is asserted, at 4,500 yards to enable this French shrapnel to do effective work.

.Within the past ten days the despatches have stated that the British authorities, recognizing the inferiority of the Woolwich made field-pieces, have placed and order for one hundred Vickers 12-pounder guns of the rapid-fire type. The Vickers weapon is said to be one of the most effective guns turned out to-day in England. It is a comparatively new piece, and this order of the British government is practically the first recognition it has received at English hands. Quite recently several mountain guns of the Vickers variety were purchased by the United States government for use in the Philippines. When we consider that the British forces at Ladysmith were only saved from early destruction or capture by the arrival of the naval 4.7-inch guns from Durban, the importance of range is brought home with marked emphasis. These naval guns were mounted on the rudest kind of structures, and happily the mounts held. Rapidity of fire and mobility were in this instaece sacrificed for range and with the result that the Boer fire was dominated.

In view of the lessons of the South African war, the progress of the ordnance authorities of this country in developing a rapid-fire field-gun will be watched, naturally, with keen interest. Experimental guns have been designed, it is learned, at the Watervliet arsenal, and comparative tests are to be made between these government pieces and special guns designed by the Driggs-Seabury Company and the American Ordnance Company. The gun submitted by the Driggs-Seabury Company has a caliber of 3 inches (the proposed standard caliber for this country) and a muzzle velocity of 1,800 foot-seconds. The carriage is remarkabiy light and simple, and both the gun and carriage weigh less, respectively, than the service piece and carriage now in use.

The present field-piece of the United States has a caliber of 3.2-inches. It was introduced into the service about seventeen years ago. It is this gun which it is proposed to replace by a weapon of 3-inch caliber, having a muzzle velocity of about 1,725 foot-seconds and using a shell weighing 15 pounds. Two years ago the Chief of Ordnance, in his report, indicated that a muzzle velocity of 1,600 feet per second would suffice, since this velocity would afford effective shrapnel results at 3,500 yards. Now it is proposed to obtain 1,725 foot-seconds, and it is gratifying to note that one of the competitors considers it practicable to use 2,800 foot-seconds at the muzzle under ordinary service conditions. When one considers that field artillery in the United States is apt to encounter country roads incomparably worse than in Europe, there is some excuse for making carriages stronger and heavier. There has been doubt expressed by many artillerists of the ability of the high-velocity Creusot carriages to stand rough service, and it will be interesting to learn how far these forebodings have been borne out. So far no complaint has been heard from the Boer side.

Up to the present time the Canet 2.95-inch, L-32, gun, and the Creusot 14-pounder 2.96-inch weapon, are recording the highest velocities among the Continental pieces. Both guns, it will be observed, are using lighter shells than the proposed new American piece. It must not be overlooked that a gun that can deliver 1,800 foot-seconds velocity to a 15-pound shell is a powerful weapon. Compare this gun with the English Woolwich-made piece, and we find the English 15-pounder employing only 1,600 foot-seconds and mounted on a carriage unsupplied with recoil-checking device. Even the Vickers gun, splendid weapon as it is, secures its 1,720 foot-seconds velocity with a shell weighing three pounds less. Of the two projectiles, the 15-pounder, by reason of its greater shrapnel-carrying capacity, to say nothing of energy, is the superior.

Bnt granting that the new guns of this country will yield 1,800 foot-seconds velocity, and this is slightly more than the authorities are indicating, the question arises : Will even that velocity assure our batteries a superiority over foreign field-guns in time of battle? Shrapnel balls, in order to inflict dangerous wounds upon horses, must possess an energy of about 282 foot-pounds. This requires, for bullets weighing forty.two to the pound, a remaining velocity of 874 foot-seconds. A muzzle velocity of 1,600 foot-seconds for a 15-pound shell yields 874 foot-seconds remaining velocity at 3,500 yards.

The shrapnel shells of guns in the hands of the Boers have been found fused for 5,200 yards. The English field-gun shrapnel is fused for 4,000 yards. Boer shrapnel, possibly from guns of the siege variety, though there is no definite information on this point, has been found effective at 5,100 yards; in other words, at a range of 1,100 yards beyond the possibilities of English field-guns. Not only have the British pieces been found weak in range, but they proved altogether too heavy both in gun and carriage. The British reports from the front summarize the needs in the demand for a gun that will shoot accurately and deliver shrapnel effectively at 5,000 yards. This will probably involve a reduction in shell weight, but judging from the guns in the hands of the Boers, it should not mean a loss of mobility.

The whole question is a most important one, and now that the United States is on the eve of adopting a new gun, the lessons from South Africa have especial value. The inventive resources of this country, and the well-known mechanical skill of its people, should make it possible to evolve a weapon the superior of any abroad. We have developed naval guns and sea-coast weapons and carriages of remarkable strength and power, but the rapid-fire field-gun of high power is lacking. There is every reason to believe, however, that this condttion will not long exist.

—*Scientific American*, January 20, 1900.

Ammunition Expended in War.

The Supply of ammunition has been a very serious question in late wars, and is becoming graver as the rapidity of fire increases. It is interesting therefore to note what has actually been expended in those campaigns, on which authentic figures are now available.

In the Italian campaign of 1859, 472 guns of the Austrian field artillery fired 15,326 shots, or an average of 32.5 per gun.

In the campaign of 1866 the Prussian artillery (900 guns) fired 36,199 shots, (34,390 shell, 1598 shrapnel, 211 canister), an average of 40 per gun; the Austrian Army of the North fired 96,472 shots (62,592 shell, 11,316 shrapnel, 2,566 canister), an average of 107 per gun. The greatest number of shots was fired by an Austrian battery of 4-pounders, which at the battle of Königgrätz fired 1738 shots, or 217 per gun, and this was the only battery which did not run out of ammunition carried in its own caissons. The next greatest number was fired by a Prussian 4-pounder battery at the battle of Pressburg, viz: 681 shots, or 113.5 per piece; and the third greatest by a 4-pounder Prussian battery of the Guards, which at the battle of Königgrätz fired 480 shots, or 80 per gun.

In the campaign of 1870-71 the Prussian artillery, including the Hessian Division, fired 267,975 shots (the 6-pounder batteries 107,126, the 4-pounders 112,770, and the horse artillery 48,079), besides 300 canister.

At Sedan alone the German artillery (Prussian, Saxon and Bavarian) fired 34,898 shots, the infantry 4,850,000 rounds; and if we assume that the French fired an equal number then at this great battle there were fired 60,000 artillery projectiles and 8,000,000 rounds of small arm ammunition.

While the average per piece, therefore, is not very high, and could readily be carried by the battery itself, the demands on particular batteries in a crisis may be enormous, and has to be provided for. Moreover, the rapidity of fire has greatly increased in the last thirty years, so that these figures only give some idea of what will be required in the way of ammunition to meet the demands of future great battles.

—*Jahrbuecher für die deutsche Armee und Marine.*

The Determination of the Jump in Guns.

By Captain John P. Wisser, U. S. A.

The electrical tuning fork has been applied to many experimental determinations, among the latest of which are those of Lieutenant Dunn, Ordnance Department, U. S. Army, (*Journal United States Artillery*, Vol. VII. pp. 29 and 213); Lieutenant Squier, U. S. Army, and Professor Crehore, Dartmouth College; and quite recently Professors Cranz and Koch, Stuttgart, Germany.

The investigations of these gentlemen on the vibrations in the vertical plane of the barrel of a rifle held horizontally constitute a noteworthy addition to the general subject of ballistics.

The cause of the so-called jump of rifles, that is, the angular difference (in a vertical plane) between the direction the projectile actually takes on leaving the muzzle of a gun and the direction it would have taken had it gone exactly as it was aimed, or, in technical language, the difference between the angle of elevation and the angle of projection, has long been veiled in mystery. The able investigators named above have undertaken the investigation of this subject, and have come to the conclusion that it is due to the vibrations set up in the gun barrel at the moment the gun is fired.

It will be remembered (see *Journal United States Artillery*, Vol. IV, No. 4, October, 1895) that Professor Crehore and Lieutenant Squier, in their investigations on a photographic method of determining the complete motion of a gun during recoil, came to the following conclusion: "It may be said, therefore, that a Springfield rifle does not move appreciably before the bullet leaves the muzzle. Even if the motion were appreciable, its direction is such that it is parallel to the axis and does not effect the aim of the gun." Professors Cranz and Koch came to a very different conclusion, and their data for this conclusion are presented graphically in the reproduced photographs herewith, of which the original article has many more.

Their method of procedure was similar to that of Professors Crehore and Squier. To show graphically that there were vibrations and to determine their character, they utilized instantaneous photography, a certain point of the barrel, during the movement of the projectile along the bore and after it left the bore, being photographed on a plate, which is moved rapidly past in the plane of the photograph. In this way the progress of the vibration of the point in question is photographed as a curve on the plate.

In order to determine the exact time for each position of the point, the vibration of a tuning fork (of known rate) is photographed on the plate at the same time, so that by counting the number of vibrations of the tuning fork (appearing as a waving line on the plate) the exact times in which the varying positions of the point occur may be readily determined.

The accompanying figures illustrate clearly how reliable and accurate their method was, and also how reasonable their conclusions. Figure 1 shows above the vibrations of the tuning fork (the time scale for all the figures), and below the vibration curve of a point of the barrel 1.5 centimetres back from the muzzle, the vertical line y indicating the instant the projectile leaves the muzzle. Figure 2 that of a point 79.5 centimetres back from the muzzle, and Figure 3 that of a point 110.5 centimetres back from the muzzle. Figure 4 shows the vibrations of a point when the trigger is pulled without having any charge in the gun.

Figure 5 is the vibration of the same point as Figure 1, but with only half the full charge. Figure 6 the same with only a quarter the charge, and Figure 7 the same with only an eigth the charge. These figures explain how the jump varies with the charge, the number of vibrations being greater as the charge is less.

This constitutes a splendid example of convincing investigation where actual observation of phenomena is impossible. The work of Professors Cranz and Koch is a classic in its way, and makes a decided step forward in the solution of the intricate problem of the jump. Although their investigations so far have been confined to a particular small arm rifle, there is no reason why the conclusions reached should not apply to rifled guns of the largest calibre. The experimenters, however, are not content with this, but propose to continue their work, to determine, if possible, all the factors that enter and modify the jump in various pieces of ordnance.

—*Electrical Review*, December 27, 1899.

BALLISTICS.

Calculating Cordite Velocities and Pressures in Ordnance.*

By A. Bremberg.

To ascertain the velocity of a projectile during its flight through the air is a fairly simple matter. To ascertain the velocity without firing the shot is a more complex problem. It may, however, be resolved, provided certain *data* are available, and also provided that such *drta* are accurately handled.

The calculation of velocities obtainable from black powder charges is an operation well known to artillery experts. With the advent of Cordite, velocities could only be worked out from the black powder tables with the help of a constant, which required to be separately ascertained for every class of gun. In this way an additional operation was necessitated; and further, it became impossible to work directly from the gun to the velocity unless someone had previously determined, by actual firing, the particular constant applying to the gun.

Like black powder, Cordite follows definite laws of combustion; and in order to provide facilities for the calculation of Cordite velocities, similar to those applying to black powder, it is necessary to build up a mathematical structure of relative values, which may be used for the direct translation of certain available *data* into certain equivalents that can be resolved into terms of velocity. This is the task which the author has set himself to perform. The result of his work is a table, specimens or sections of which have been reproduced for the purpose of this description. How the table has been built up, how many examinations of actual firings have been carried out, how many times it has become necessary to enter into fresh lines of enquiry to clear up certain moot points, are not matters of present concern. The table having been put together, it only now remains to describe its application to actual problems, and to work out a series of examples. By this means the equivalent values given in the table may be checked against results obtained by direct measurements.

ROOT PRINCIPLES OF THE CALCULATION.

On ignition of the charge in a gun, the pressure on the base of the shot will rapidly rise until it is powerful enough to overcome the friction between the copper driving band and the rifling, and the shot is started and moved along the bore of the gun with an accelerated velocity. During the earlier stages of the shot's forward movement the powder pressure continues to increase, and goes on increasing up to a certain point. When this point of maximum pressure has been reached, the whole of the charge has been consumed and transformed into gas provided (*a*) that the diameter of the cords is not abnormally large, or (*b*) that the maximum pressure is not very low.

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* When this article was first submitted to us the material seemed to be more suitable for production in permanent book form. After careful consideration, we decided to publish particulars of the system of calculation, together with sections of the Table which accompanied the letterpress. We have also decided to republish the complete description and Table separately at the price of 10s. per copy, and we anticipate having the book ready towards the end of the current month. [Ed. *A. & E.*]

VIBRATIONS OF DIFFERENT POINTS OF A RIFLE BARREL.

The vertical line γ marks the instant the projectile leaves the muzzle.

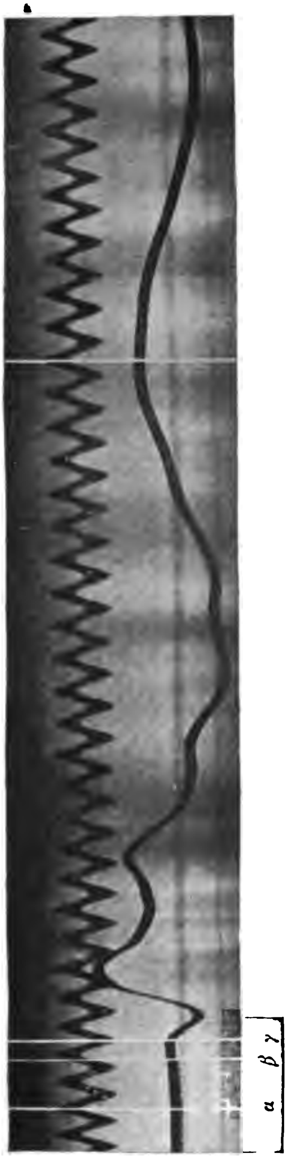


FIG. 1. — Curve of vibration of a point 1.5 cm. from muzzle.

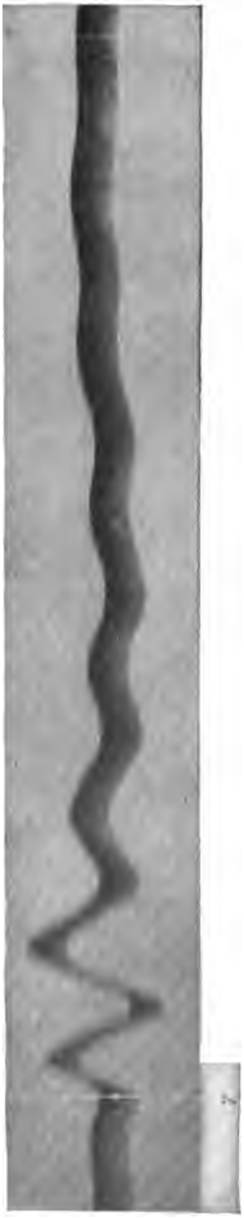


FIG. 2. — Curve of vibration of a point 55.0 cm. from muzzle.

The powder chamber represents so much lost power in the propulsive effect of the powder charge. Hence it follows that the volume of the air space in the chamber must be deducted from the total energy produced by the combustion of the powder charge.

The total expansions in the bore represent the expansion of the powder charge from its original bulk up to the moment when the shot leaves the muzzle. The *effective* portion of this expansion is obtained by deducting the *ineffective* portion represented by the expansion in the chamber. The effective portion of the work done by the powder charge is, therefore, the expansions which take place beyond the chamber and up to the muzzle. These expansions have a definite energy value, which are governed by the inherent properties of Cordite as an explosive. The table shows the energy values of a number of different expansions of one pound of Cordite. The expansions within the chamber are a minus quantity, and from the energy value of the total expansions up to the muzzle this minus quantity must be deducted. The effective energy of the powder charge is not wholly transmitted to the shot, and the amount so transmitted depends upon the rapidity with which the charge is resolved into gas—in other words, upon the position the shot has reached when the gases have attained maximum pressure. This position is expressed for the present purpose in terms of the number of expansions which have occured up to the point of maximum pressure. By allowing for the position of maximum pressure the amount of energy transmitted to the shot by each pound of the charge is available. This is muzzle energy, and muzzle energy is readily converted into terms of velocity.

ESSENTIAL FACTORS OF THE CALCULATION.

The velocity of a projectile is the product of a number of conditions which require to be considered in detail, viz. :—

Weight of shot.
Weight of charge (Cordite).
Size or Gauge of the Cordite.
Capacity of the Chamber.
Capacity of the Bore.
Sectional Area of the Bore.

From the data quoted above the three following factors, which are necessary for the calculation, may be found :—

Number of Expansions in Chamber.
Number of Expansions in Bore.
Number of Expansions at Maximum Pressure.

The number of expansions in the chamber is obtained by dividing the total capacity of the chamber (in cubic inches) by the weight of the charge (in lbs.), and by 27.73. Thus :—

$$\frac{\text{Capacity of chamber (in cubic inches)}}{\text{Powder charge (in lbs.)} \times 27.73}$$

The value 27.73 is a well-known standard, and represents the conventional volume in cubic inches of 1 lb. of water. It is here taken as the capacity of one pound of Cordite at unit expansion.

The total expansions in the bore are obtained from the total capacity of the bore in the same way as the expansions in the chamber, viz. :—

$$\frac{\text{Total capacity in bore (in cubic inches)}}{\text{Powder charge (in lbs.)} \times 27.73}$$

In this way the numerical values of two of the factors in the second list are resolved. The next and last factor to determine by calculation is the number of expansions of the gases behind the projectile which have taken place up to the point of maximum pressure. Before dealing with the calculation of expansions at maximum pressure, it will be necessary to refer to the table.

THE TABLE.

In the complete table (portions only of which are here reproduced) column No. 1 gives a number of expansions from 3.2 volumes up to 30 volumes. Column No. 2 gives the work in foot-tons which one pound of Cordite performs in expanding from 3.2 volumes (the starting point of the table) to any other number of volumes which are recorded. Intermediate values are obtained by subtraction. For instance, the expansion from 3.45 volumes to 5.35 is obtained by deducting the equivalent in foot-tons from 3.45, viz., 13.86 foot-tons, from the equivalent in foot-tons of 5.35, viz., 90.70 foot-tons. Thus :—90.7—13.86=76.84 foot-tons.

Column No. 3 gives the pressures in tons per square inch, corresponding with the various numbers of expansions shown in column No. 1. The pressures given are not closed-vessel pressures, but are rather less, since they represent the presures of Cordite while expanding and doing work.

Column No. 4 contains a series of constants depending upon the number of expansions at maximum pressure, as used in the calculations.

The equivalents in columns 3 and 4 are only carried as far as experience shows to be necessary.

VELOCITY OF A 12-INCH GUN.

A point has now been reached when an actual example may be quoted, viz., the Government 12-inch Mark VIII. gun.

Weight of shot, 850 lbs.
Charge, 162 lbs. of 50 gauge Cordite.
Capacity of the chamber, 13,403 cubic inches.
Capacity of bore, 54,551 cubic inches.
Sectional area of bore, 114.9 square inches.

To find the expansions in the chamber as already described, the following calculation is made :—

$$\frac{13403}{162 \times 27.73} = 2.983$$

The total expansions in the bore are likewise found as follows :—

$$\frac{54551}{162 \times 27.73} = 12.1$$

These calculations involve the determination of the number of expansions at maximum pressure. In all investigations connected with the theoretical working out of velocities, it is necessary to see what would be the maximum pressure produced under the conditions of the problem. No separate calculation is required for this, since the third column of the table gives the maximum pressures corresponding with the wide range of expansions to be found in column No. 1.

The number of expansions at the point of maximum pressure is determined as follows :—

No. of Expansions.	Energy in Foot-tons.	Corresponding Pressures in Tons per square inch.	Constants.		No. of Expansions.	Energy in Foot-tons.
3.85	33.72	20.32	36.52		11.7	212.10
3.9	36.02	20.01	35.96		11.8	213.32
3.95	38.29	19.70	35.41		11.9	214.53
4.	40.53	19.41	34.88		12	215.73
4.05	42.73	19.12	34.37		12.1	216.91
4.1	44.90	18.84	33.86		12.2	218.08
4.15	47.04	18.57	33.38		12.3	219.24
4.2	49.15	18.30	32.90		12.4	220.39
4.25	51.23	18.05	32.44		12.5	221.53
4.3	53.28	17.79	31.98			
4.35	55.30	17.55	31.54		* *	* *
4.4	57.29	17.31	31.11			
4.45	59.26	17.08	30.69		16	255.58
4.5	61.20	16.85	30.28		16.1	256.42
4.55	63.12	16.63	29.88		16.2	257.25
4.6	65.01	16.41	29.49		16.3	258.08
4.65	66.87	16.20	29.11		16.4	258.90
4.7	68.71	15.99	28.74		16.5	259.72
4.75	70.53	15.79	28.38		16.6	260.53
4.8	72.33	15.59	28.02		16.7	261.33
4.85	74.10	15.40	27.68		16.8	262.13
4.9	75.85	15.21	27.34		16.9	262.92
4.95	77.58	15.03	27.01		17	263.70
5.	79.28	14.85	26.68		17.1	264.48
5.05	80.97	14.67	26.36		17.2	265.25
5.1	82.64	14.50	26.06		17.3	266.02
5.15	84.29	14.33	25.75		17.4	266.79
5.2	85.92	14.17	25.46		17.5	267.55
5.25	87.54	14	25.17		17.6	268.30
5.3	89.13	13.85	24.88		17.7	269.05
5.35	90.70	13.69	24.60		17.8	269.79
5.4	92.26	13.54	24.33		17.9	270.53
5.45	93.80	13.39	24.06		18	271.26
5.5	95.32	13.24	23.89		18.1	271.99
5.55	96.83	13.10	23.53		18.2	272.71
					18.3	273.43
* *	* *				18.4	274.14
					18.5	274.85
9.7	184.73				18.6	275.56
9.8	186.25				18.7	276.26
9.9	187.76				18.8	276.95
10.	189.25				18.9	277.64
10.1	190.72				19	278.33
10.2	192.17				19.1	279.01
10.3	193.61				19.2	279.69
10.4	195.03				19.3	280.36
10.5	196.43				19.4	281.03
10.6	197.82				19.5	281.70
10.7	199.19				19.6	282.36
10.8	200.55				19.7	283.02
10.9	201.89				19.8	283.67
11.	203.21				19.9	284.31
11.1	204.51				20	284.97
11.2	205.81				20.5	288.14
11.3	207.00				21	291.22
11.4	208.36				21.5	294.21
11.5	209.62				22	297.12
11.6	210.87				22.5	299.95

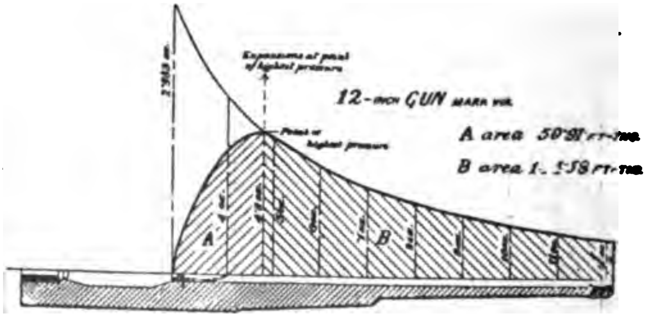
$$\frac{\text{Chamber in cubic in.}}{\text{Charge (in lbs)} \times 27.73} \times \left[1 + \frac{\text{Constant} \times \text{sectional area of bore (in square inches)}}{\sqrt{\text{Chamber (in cubic inches)} \times \text{shot (in pounds)}}}\right]$$

The constant used in this formula varies with different sizes of Cordite. For size 10 it comes to 3.9, size 15=6.6, size 20=10.5, size 30=16, size 50=18. These constants are calculated from powder fired which has a temperature of 80 deg. F. According to the Government text book, the pressure rises .1 of a ton for each degree F. Hence the number of expansions at the point of maximum pressure is:

$$\frac{13403}{162 \times 27.73} \times \left[1 + \frac{18 \times 114.9}{\sqrt{13403 \times 850}}\right] = 4.8$$

In other words we have 4.8 expansions at the point of maximum pressure. According to the table, one pound of Cordite expanding from 4.8 volumes to 12.1 volumes (viz., the total expansions in bore) transmits an energy to the shot equal to 216.91—72.33=144.58 foot-tons.

The diagram here reproduced shows graphically what this value of 144.58 foot-tons represents. The curve indicates pressure along the barrel, the vertical height representing pressures, the horizontal distances showing expansions based upon the measurements of the bore of the gun which is shown at the bottom of the diagram. The calculatioas so far made show that from the point of maximum pressure up to the muzzle, an amount of work equal to 144.58 foot-tons has been performed by each pound of powder. The area enclosed by the pressure curve represents the total amount of work done from the first movement of the shot up to the time the shot has reached the muzzle. This total area is divided into two sectlons, viz., A and B, the amount of work done beyond the point of maximum pressure, viz., 144.58 foot-tons, being the B section of the area enclosed by the curve. To Longridge belongs the credit for the separation of the pressure curve into these two sections.



The next operation is to find the work performed from the first movement of the shot up to the point of maximum pressure, viz., the A section of the area enclosed by the curve. This is effected by subtracting the expansions in the chamber from the expansions at maximum pressure (4.8—2.983=1.817), and multiplying the result by the constant in column No. 4, which applies to 4.8 volumes. This constant is 28.02, and hence we have the energy in foot-tons of the A portion of the diagram (1.817 × 2802=50.91 foot tons).

The total energy imparted to the shot by every pound of Cordite is, therefore, the sum of the A and B sections of the curve, viz., 50.91 + 144.58= 195.49 foot-tons. Since this is the energy transmitted by each pound of the charge of Cordite acting upon the whole weight of the shot, we must multiply 195.49 foot-tons by the weight of the charge (162 lbs.) to find the total energy transmitted to the shot, and divide by the weight of the shot (850 lbs.) in order to find the energy stored up in each pound of the shot on leaving the muzzle, viz. :—

$$\frac{195.49 \times 162}{850}=37.258 \text{ foot-tons.}$$

Having now arrived at the knowledge that each pound by weight of the shot leaves the muzzle with a stored up energy of 37.558 foot-tons, we may obtain the velocity corresponding to this energy from an ordinary energy table. The result is 2,318 foot-seconds. The reason for dividing above by the weight of the shot is now apparent, since by reducing the total energy to that stored up by each one pound by weight of the shot, we are enabled to use an energy table based upon the unit of one pound, in place of making a special calculation for determining the velocity from the energy.

Comparing the theoretical results of the calculations and Table with actual firing experience, we obtain the following :—

Calculated velocity	2,318 foot-seconds.
Observed velocity	2,327 " "
Divergence	9 " "

In the same way we may compare calculated with observed pressures. The expansions at maximum pressure were 4.8, which the Table shows to correspond with a pressure of 15.59 tons per square inch. The comparison with actual results is as follows :—

Calculated pressure	15.59 tons per sq. inch.
Observed pressure	15.50 " "
Divergence	.09 " "

CALCULATION ALGEBRAICALLY EXPRESSED.

Before going further, the information and instructions already given may be summarized in the manner customary for such calculations. Therefore let

X = Muzzle Energy of Each Pound of the Shot (in foot-tons).
W = Weight of shot in pounds.
w = Weight of Charge of Cordite in pounds.
K_1 = Constant Varying with Size of Cordite.
c = Capacity of Chamber in Cubic Inches.
C = Capacity of Bore in Cubic Inches.
A = Sectional Area of Bore in Cubic Inches.
e_1 = Number of Expansions in Chamber.
e_2 = Number of Expansions in Bore.
e_3 = Number of Expansions at Maximum Pressure.
E_2 = Energy in Foot-tons corresponding with e_2 (see Table).
E_3 = Energy in Foot-tons corresponding with e_3 (see Table).
K_2 = Constant for e_3 (see Table).

$$e_1 = \frac{c}{W \times 27.73}$$

$$e_2 = \frac{C}{W \times 27.73}$$

$$e_3 = \frac{c}{W \times 27.73} \times \left[1 + \frac{K_1 \times A}{\sqrt{c \times W}} \right]$$

Find value of e_2 in column No. 1 of Table, and the adjoining number in column No. 2 is the numerical value of E_2. Find E_3 from e_3 in the same manner.

Find value of e_3 in column No. 1 of Table, and the number in column No. 4 on the same line is the numerical value of K_2.

$$X = E_2 - E_3 + [(e_3 - e_1) \times K_2].$$

Convert X into velocity with Energy Table.

VARIOUS EXAMPLES.

Various results with other guns are tabulated below. In some cases it will be seen that the calculated and observed velocities are but a few feet apart. Such coincidences are, of course, accidental, since velocities could never be calculated with such perfection.

In some cases it will be seen that corrections of 5 *per cent.* and 2 *per cent.* have been made on the velocities obtained from the calculations. A deduction of 5 *per cent.* serves to bring the calculated volocities to a level with those published in the Government text books. These latter are taken under Service conditions, when the guns have been worn, and the velocities thus obtained are about 5 *per cent.* lower than those from proof firing with new guns to which the values of the Table apply. The 2 *per cent.* may be used as a correcting factor between Cordite and Chilworth Cordite, which latter is really the "Ballistite" composition. Chilworth Cordite, other things being equal, gives about 2 *per cent.* higher velocities than true Cordite of official

	Hotchkiss 3 pr. 40 cal.	3-inch Q.F. 40 cal.	4.7-inch Q.F. 40 cal.	6-inch Q.F. 40 cal.	12-inch Mark VIII.
Value of W	3.3	12.5	45	100	850
" w	.4325	1.9375	5.4375	13.25	195
" K_1	1.75	6.6	10.5	16	18
" c	42.3	125	278	715	13,403
" C	208.4	873	3,367	6.964	54,551
" A	2.735	7.2	17.8	28.7	114.9
" e_1	3.486	2.326	1.843	1.946	2.478
" e_2	17.2	16.2	16.2	18.95	10.1
" e_3	4.9	5.15	4.95	5.25	4
" E_2	265.25	257.25	299.95	278	190.72
" E_3	75.85	84.29	77.58	87.54	40.53
" K_2	27.34	25.75	27.01	25.17	34.88
Calculated Velocity	2,088	2,344	2,310	2,286	2,593
Do. less 5 per cent.		2,227	2,195	1,172	
Do. less 2 per cent.	2,046				
Observed Velocity	2,047	2,235 ± 35	2,185 ± 25	2,200 ± 25	2,588
Calculated Pressure	15.2	14.33	14.33	14.0	19.41
Observed Pressure	15.1	15.0 (less than)	15.5 (less than)	16.0 (less than)	19.25

specification. The Table gives Chilworth Cordite results, and velocities must be reduced 2 *per cent.* to read in Cordite velocities. The pressures obtained by the use of the Table are substantially correct for either explosive.

It will be seen that no correction has been made in the case of the 12-inch gun quoted at length in the article, nor in the same gun with a bigger charge shown in the tabulated results. This is because the observed velocity quoted is that of the proof rounds. No doubt when the gun is described in the official text books, the figures quoted will be about 5 per cent. less.

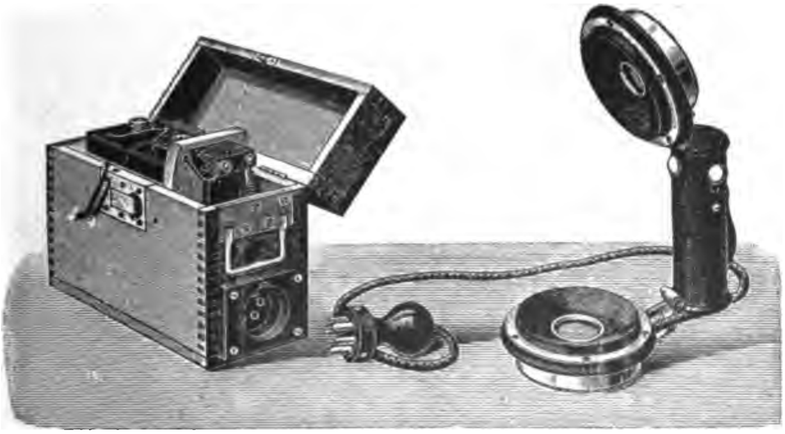
FIELD EQUIPMENTS.

A New Military Telephone.

By Captain John P. Wisser, U. S. A.

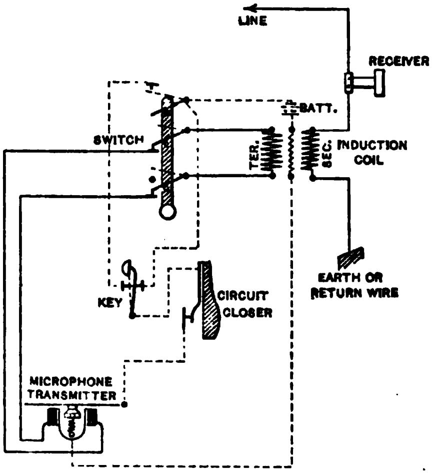
The telephone has many advantages over the telegraph, but in war the most important conditions to be fulfilled by all pieces of apparatus are facility of transportation and manipulation, and certainty of action, and in these respects the telegraph has undoubted advantages still. However, the immense advantages of the telephone, when it can be used (whether it will ultimately displace the telegraph in war or not), will cause it to be used as long as it will work. Now, if our telephone system gets out of order and we have to unpack and connect a telegraph in its place, much valuable time will be lost, hence Siemens and Halske, the well-known manufacturers of electrical apparatus, have introduced a combined field telephone and telegraph (fully described in *Schweizerische Militärische Blätter*, October, 1899), which may be used at will for phonic or telephonic telegraphy.

The military field telephone is especially important at the outposts of an army in camp, or with the patrols of the advance guard on the march, and to meet the requirements of its application there, it must be strong, simple in construction, light and reliable, and the elements of the battery used with it must be strong, durable and chemically stable. The first three conditions (strength, simplicity and lightness) can be readily combined, but all previous methods of obtaining also a reliable call arrangement have too greatly increased the size and weight of the whole. This difficulty the new apparatus appears to have overcome.

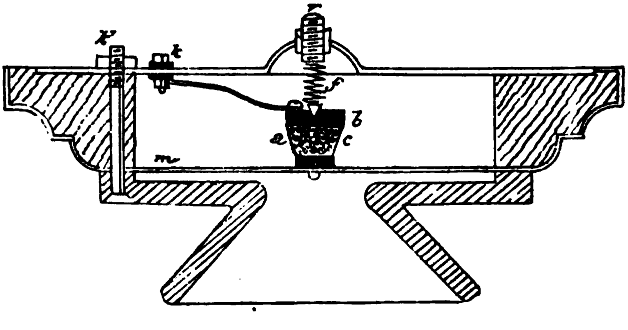


The Field Equipment.

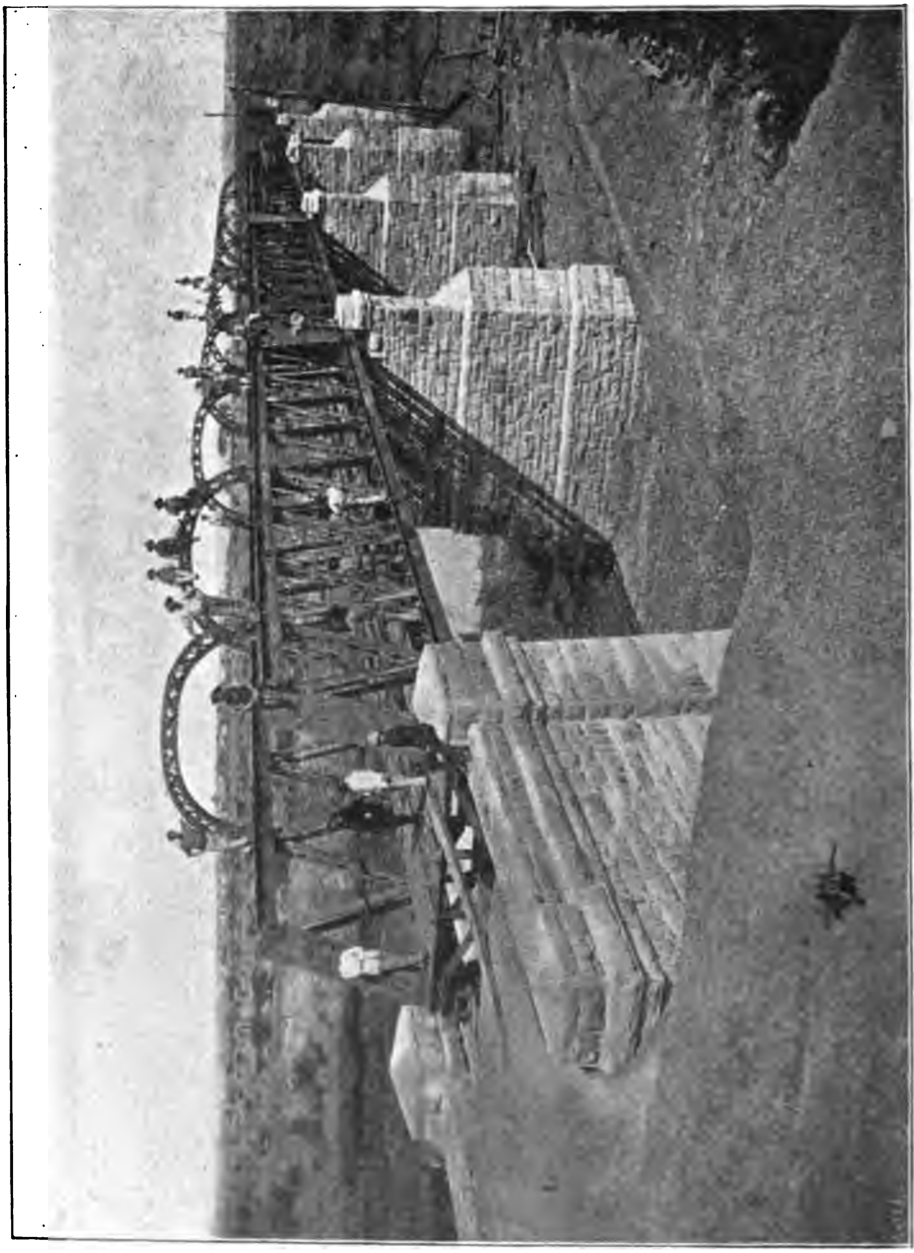
The entire outfit comprises a wooden battery chest and a leather telephone case, the whole weighing about nine pounds. The microphone (which is very sensitive, can be used in any position, and emits clear tones) is connected with the receiver through a cylinder containing the switch, the circuit closer and the key; and connection with the battery chest (which contains the battery and induction coil) is effected by means of a wire of several strands, contact being made by inserting a contact pin. The battery is composed of two dry cells (electro-motive force 1.5 volts, resistance 0.8 ohms). The connections at a single station are indicated in the diagram, the full lines showing the switch and key in the position of "calling or telegraphing," the dotted lines when "telephoning or speaking." In the first case, by depressing key and circuit closer the primary circuit is made and a current is induced in the tertiary wire, which by weakening the permanent magnet in the microphone causes the diaphragm to move out. But this motion causes the bag of granulated carbon to be elongated, thus (by diminishing the diameter of this conductor) increasing the resistance, causing diminution of primary current and a consequent reverse current in the tertiary wire; by this reverse current the diaphragm is made to move in, which bulges out the



The Connections.



Microphone.



carbon bag, diminishing the resistance, and so on. These induced currents, repeated in the secondary wire, cause a distinctly audible humming sound both in our own telephone receiver and in that of the corresponding station. In the second case (practically effected by simply moving a button on the cylinder which brings the switch to the proper position, and letting go the key) the electro-magnet is cut out, and we have merely an ordinary telephone circuit, the microphone becoming the transmitter.

Aside from the intrinsic qualities of this instrument, it possesses, as a field apparatus, the great advantage of enabling the operator to pass readily from telephone to telegraph.

—*Electrical Review*, January 3, 1900

MILITARY ENGINEERING.

The Frere and Tugela Bridges.

The reproductions of photographs which we publish give an excellent idea of the wreckage which the "simple minded" farmers, and their French and German colleagues, now in arms against us, have been able to effect. Figure 1 of these illustrations represents the state in which the Frere Railway Bridge was found on the retreat of the Boers to Colenso. The bridge is a pin-connected structure erected on the first construction of the railway several years back, and the wreckage has apparently been effected by smashing each truss above and below by means of gun-cotton or dynamite, with the results shown.

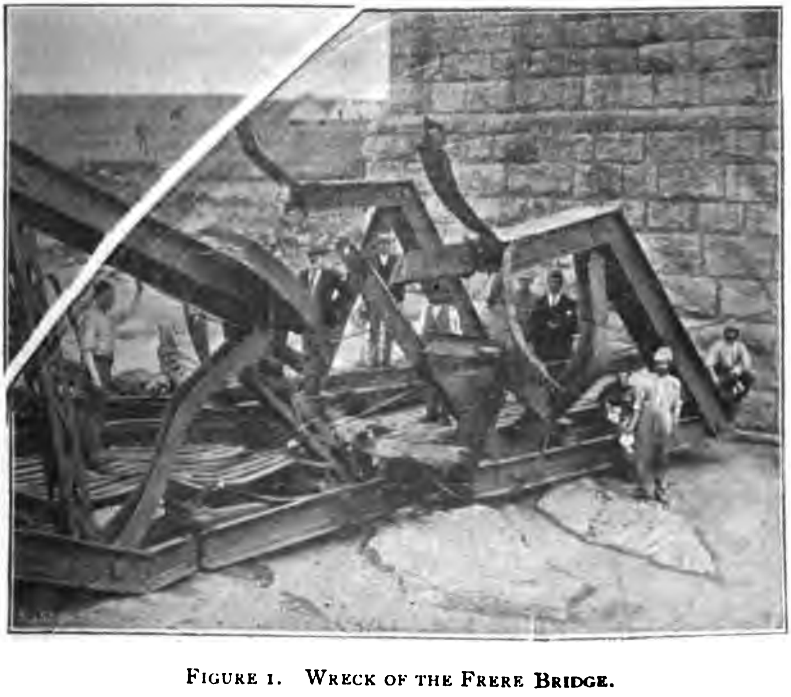


FIGURE 1. WRECK OF THE FRERE BRIDGE.

Curiously enough, the masonary of the piers and abutments has entirely escaped injury, not a single stone having been displaced by the fall of the girders.

It will be noticed that the curved braces connecting the top chords are exceptionally lofty. This is necessitated by the great height to which the wool wagons are loaded, requiring as they do 13 feet 6 inches in the clear between rail level and the lowest point of any overhead structure. Of course, the damage done by the enemy has been by no means confined to the destruction of the bridges at Frere and Colenso. Culverts, which are very numerous, have beeh blown up wholesale, rails torn up, and in some cases the sleepers burnt, but the trouble and delay thus caused are minor matters as compared with the wreckage of the Frere and Tugela bridges. The damage done to the latter has not yet been fully ascertained, though natives report that every span has been blown up. Our illustration, figure 3, shows it as it originally appeared. It consisted of five pin-connected spans, each of 100 feet in the clear, whilst the Frere Bridge consisted of two such spans. The temporary bridge replacing the latter is well shown by figure 2, annexed. It is, it will be seen seen, of simple trestlework, founded upon timber sills laid on concrete blocks, formed in trenches sunk in the river bed, which, it appears, was almost bare of water at the. the time the photograph was taken. The river is, however, subject to very violent floods, necessitating the provision of an ample waterway. These floods are, however, limited to one season of the year, and during the remaining months the bed is nearly dry as shown. This fact naturally much simplifies bridge erection in general, as when it is possible to postpone matters to a favorable portion of the year, simple piles or cribs of sleepers provide all the false work necessary. The difficulty of temporarily repairing the damages is much increased owing to the fact that all timber has to be imported.

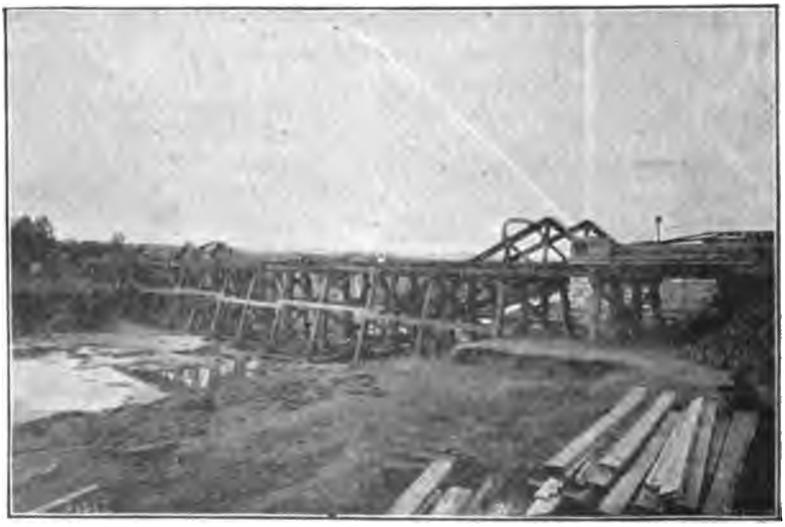


FIGURE 2. TEMPORARY BRIDGE AT FRERE.

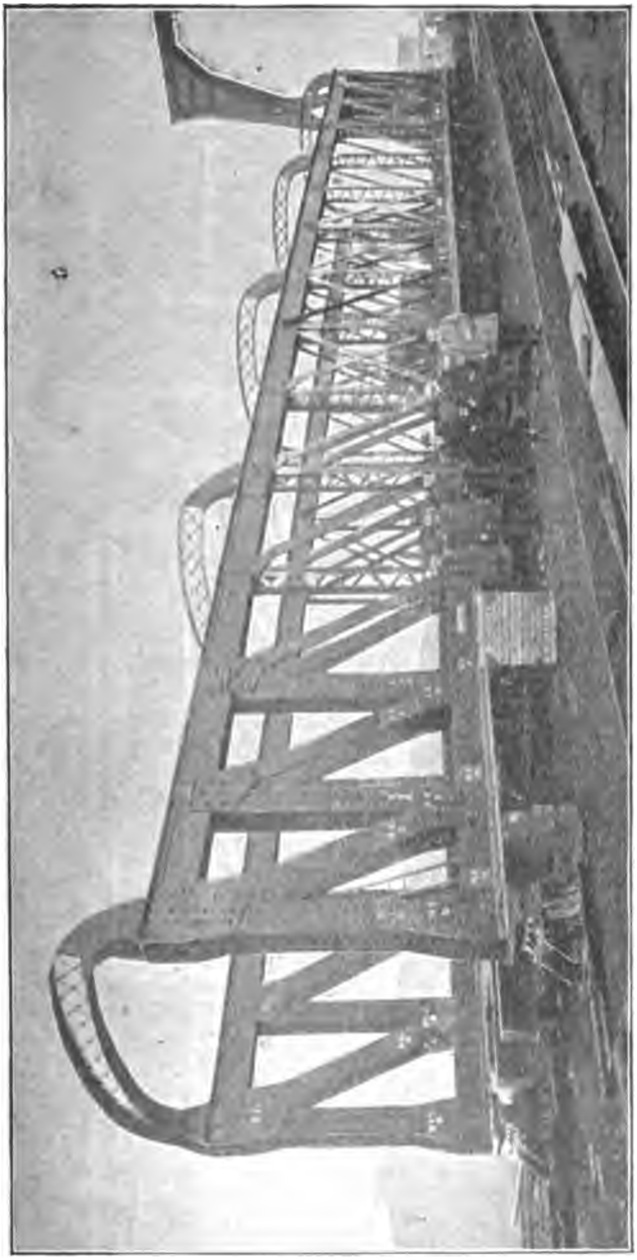


Figure 4. One Span for New Railway at Colenso.

The contract for the new bridges to replace the wrecked structures at Frere and Colenso was entrusted to the Patent Shaft and Axletree Company, Limited, of the Old Park Works, Wedensbury. The order was given on

December 21, last, and in sixteen working days the first span was completed, whilst the second span was completed by January 18. A third span was ready this week, and the last span will, the constractors state, be completed by the end of February. Each span measures 105 feet over all, is 16 feet wide, and 16 feet in extreme depth. These figures fail however, to do justice to the contractors, for each span is of the extraordinary weight of 105 tons. The reasons for this excessive weight will appear clearly on reference to our photograph, showing the completed structure as it stood in the builder's yard. Had more time for the preparation and discussion of more modern designs been possible, Mr. M. W. Carr, the consulting engineer to the Natal Government, informs us that he could have obtained a bridge at least equally strong, weighing not more than 45 tons per span. The possible saving was thus enormous, particularly in view of the fact that the whole material has to be transported a distance of 7000 miles. The matter was, however, urgent, and, to avoid possible delay, Mr. Carr reluctantly decided to make use of the designs shown, which were, we are told, prepared by a well-known firm of consulting engineers in Westminster two or three years ago, and were immediately available. As will be seen, the bridge is of what we may perhaps call the early Victorian type, and the lack of economy in the design is obvious. The shallow depth of girder necessitating the curved braces between the top booms, the small panel length, there being no less than 14 panels to a span of 105 feet, which almost doubles the weight of the floor and web members, all point to the disadvantages of the usual English methods of bridge desingn, in which the full details of a structure are commonly worked out in the office of a consulting engineer, who very frequently has been too busy with general engineering work to keep up to date in the science of constructional iron work. Of course, some of these engineers are, like Sir Benjamin Baker, for instance, specialists in bridge design, and to them our remarks do not apply; but others, as our engraving shows, have quite failed to keep pace with modern advances in the theory of structures. In some other countries nine bridges out of ten are built and designed by the one firm, a consulting engineer only being called in when the work is of unusual magnitude or difficulty. As a consequence, each firm of contractors keeps a highly qualified staff whose business is to prepare the competitive designs submitted to railway engineers and others requiring bridges. Each firm has, therefore, its own standard details, which, being repeated in structure after structure, have an immense amout of care expended on them in the first instance, to insure that they shall not only be thoroughly efficient, but shall also be capable of economical production. English bridgebuilders, on the other hand, are liable to have to provide an entirely different set of details for every new contract, and it is thus impossible for them to lay out their plant with a special reference to the production of any one type. The rolling load for which the bridge was designed is, we understand, one and a half tons per foot. Contrary to what has been stated in certain press organs, it is intended for rail traffic only, and has consequently an open floor, though a light gangway intended for the use of the permanent-way men will be added on each side of the rails.

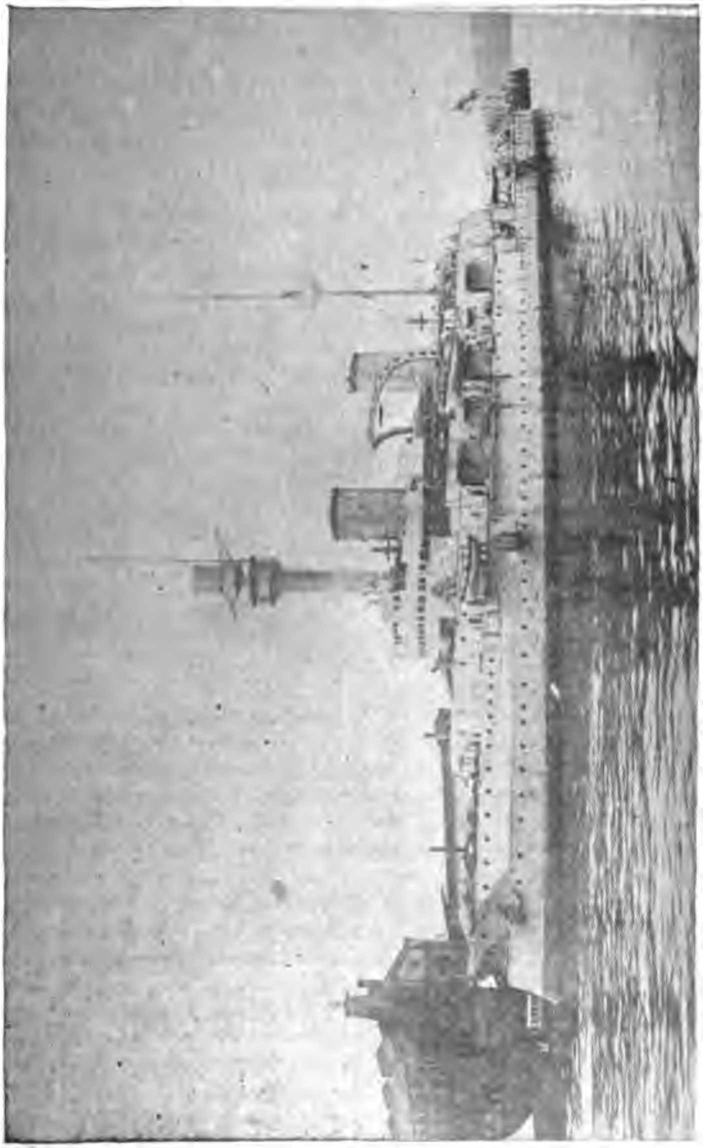
For much of the information above given we are indebted to Mr. Carr, who also supplied us with the photographs representing the original Tugela Bridge, the wreckage at Frere, and the temporary bridge erected by the military engineers.

—*Engineering*, January 26, 1900.

WARSHIPS AND TORPEDO BOATS.

The German Ships-of-the-Line of the *Kaiser Friederich III* Class.

Of the five new ships-of-the-line of the German Navy,—*Kaiser Friederich III*, *Kaiser Wilhelm II*, *Ersatz König Wilhelm*, and the two "A" and "B," provided for in the naval budget for 1898—the first, constructed at the royal docks at Wilhelmshaven, is now being completed. The time fixed for the



German Battleship *Kaiser Friedrich III.*

Rivista Marittima.

completion of the *Kaiser Wilhelm II* (Wilhelmshaven docks) is the spring of 1899, that for *Ersatz König Wilhelm* (Germania docks in Kiel) 1901, that for "A" (docks of Blohm and Voss, Hamburg) and "B" (docks of F. Schichau, Danzig) the year 1902.

The new battleships, which are constructed according to the designs of the late Professor Dietrich, Chief Engineer in the royal navy,. constitute a new type, peculiar to the German navy, and differ considerably from the battleships of the *Brandenburg* class.

They are characterized, as regards their construction, by the high bow and the low freeboard of the stern, and as regards their military value by the extremely advantageous distribution of the artillery, which gives them great offensive power with relatively little displacement.

The new ships are 357 feet long and 66 feet beam, with a draught of 24 feet and a displacement of 11,080, tons. The German naval authorities have not as yet been able to make up their minds to construct ships of such collosal dimensions as the English and Japenese battleships of over 15,000 tons. Limitation to certain dimensions is at present compelled by the existing dock facilities ; morever, with them the principle obtains that the battleships should be so constructed as to combine as many desirale qualities as possible, thus giving them not only the greatest maneuvering power and the best sea-going qualities, but also the highest military value.

The ships are built entirely of steel. The plates and angle irons are partly from the Krupp Works and partly from the Guten Hoffnung Works. The cellular system (watertight compartments) has been carried to such a degree as to border on discomfort in intercommunication, and under the armored deck no compartment is accessible from its neighboring compartments. The strongly arched, 2.6 inch armored deck protects the engines and boilers, the ammunition magazines, the torpedo store-rooms, and the steam steering apparatus, and increases in thickness in the last fifth of the ship's length to 3 inches. A cork cofferdam along the water-line serves to increase the buoyancy.

The armor protection of the ship extends only for four-fifths of its length from the bow, and consists of an armor belt, 6.56 feet wide and from 11.8 to 5.9 inches thick, tapering to a smaller thickedness below, composed of nickel-steel, face hardened. This armor. made at the Krupp Works, has a resisting power of about 30 per cent. higher than the ordinary nickel-steel, with which the ships of the *Brandenburg* class are armored. It was possible, therefore, to reduce the thickness from 15.75 inches (*Brandenburg* class) to 11.8 inches in the *Kaiser Friedrich*. Nevertheless, the total weight of armor protection, including that of the gun turrets, casemates, conning tower, and ammunition shafts amounts to about 30 per cent. of the total displacement.

The turrets for the 24 cm. (9.45 inch) guns are 9.8 inch thick; those of the 15 cm. (5.9 inch) guns and casemates 5.9 inch thick ; and the forward conning tower is 9.8 inch and 3.9 inch thick.

The entire armament consists of rapid-fire guns, including the new 40 caliber Krupp 24 cm. (9.45 inch) guns, having a length of tube of 9.6 m. which are placed in pairs in the forward and the after gun turrets. The caliber as well as the number of heavy guns has been reduced in the new ships of the line. The four ships of the *Brandenburg* class carry six 28 cm. (11 inch) guns. This reduction was made to save weight and also to favor the medium caliber guns, the amount of which has been correspondingly increased. The artillery comprises the following :

Four 23 cm. (9.45 inch) rapid-fire guns in revolving turrets.

Nine 15 cm. (5.9 inch) rapid-fire guns in revolving turrets.
Nine 15 cm. (5.9 inch) rapid-fire guns in armored casemates.
Twelve 8.8 cm. (3.5 inch) rapid-fire guns behind steel shields.
Twelve 3.7 cm. (1.46 inch) revolving cannon.
Twelve 8 mm. (0.315 inch) machine guns.
Six torpedo tubs for 45 cm. (18 inch) torpedoes of special constrnction.

The arrangement of the guns is such that, including the 8.8 cm. rapid-fire guns, a broadside of 148 shots a minute, with a weight of projectiles of 93,368 pounds and an energy of 531,000 foot pounds may be fired.

This arrangement of the guns is of especial interest, and differs considerably from that adopted by other navies. The entire armament is at six different heights. The lowest contains the guns of the after turret, with 13 feet freeboard, and four 15 cm. (5.9 inch) rapid-fire guns, standing in corner casemates. At the next height are the rest of the 15 cm. rapid-fire guns, partly in revolving turrets, partly in armored casemates (protected in rear as well as in front, with 20 feet freeboard.) The next height contains the guns of the forward armord turret, lying 26 feet over the water, which can therefore be used even in a moderately high sea. At nearly the same height, on the deck of the superstructure, there are ten 8.8 cm. rapid-fire guns and two 3.7 cm. machine guns. With 39 feet freeboard stand the four 3.7 cm. machine guns on the lower forward bridge, and two similar pieces on the bridge over the after conning tower. At the fifth stage, on the forward upper bridge, with 46 feet freeboard, are two 8.8 cm. rapid-fire guns. Finally, 79 feet over the water, in the fighting tops, there are four 3.7 cm. machine guns. The 12 8 mm. machine guns are placed at various points of the superstructure.

The new ships of the line have three engines and three screws. The engines are vertical and triple expansion and develop an indicated horse-power of 13,000. Each engine is located in a special compartment, accessible only through the armored deck, and protected against shell by means of a steel covering above. The speed of the ships is 18 knots.

The three screws have each a diameter of about 13 feet, and are made of bronze, the screw shafts are hollow and made of Krupp cast steel. The two side shafts are protected by a coating of vulcanized rubber, over which is a steel mantle.

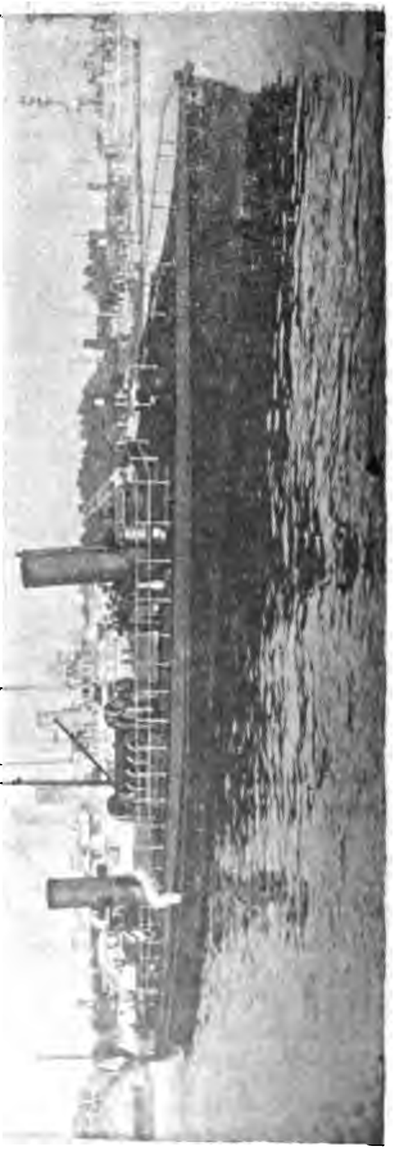
The coal capacity of the bunkers is 650 tons, but a total of 1000 tons can be carried.

Great attention is paid to the comforts of living on board. All the quarters for officers and men are high, and well ventilated, lighted and warmed. In consequence of the principle adopted in the German navy, of strictly limiting all wood constructions to what is absolutely necessary, a principle sustained by the experiences in the naval battles of the Yalu, of Cavite and of Santiago, the living room on board modern warships has been greatly reduced. But in these new ships of the line special efforts have been made to secure a proper amount. The bulkheads and doors of all quarters and mess rooms are first covered with a layer of cork 0.8-inch thick, over which is a covering of cloth. By way of experiment, certain of the rooms have also been covered with wall paper of pressed aluminium. The furniture tables and benches constitute the only wood-work aboard. Experiments with aluminium furniture proved unsatisfactory. For covering the deck, besides the ordinary linoleum, a new material, called *torgament* was tried. It is composed mainly of saw dust, and is prepared by mixing the latter with a liquid, and is made up in sheets about 0.4 inch thick. It appears to work well, but costs $1.25 per pound.

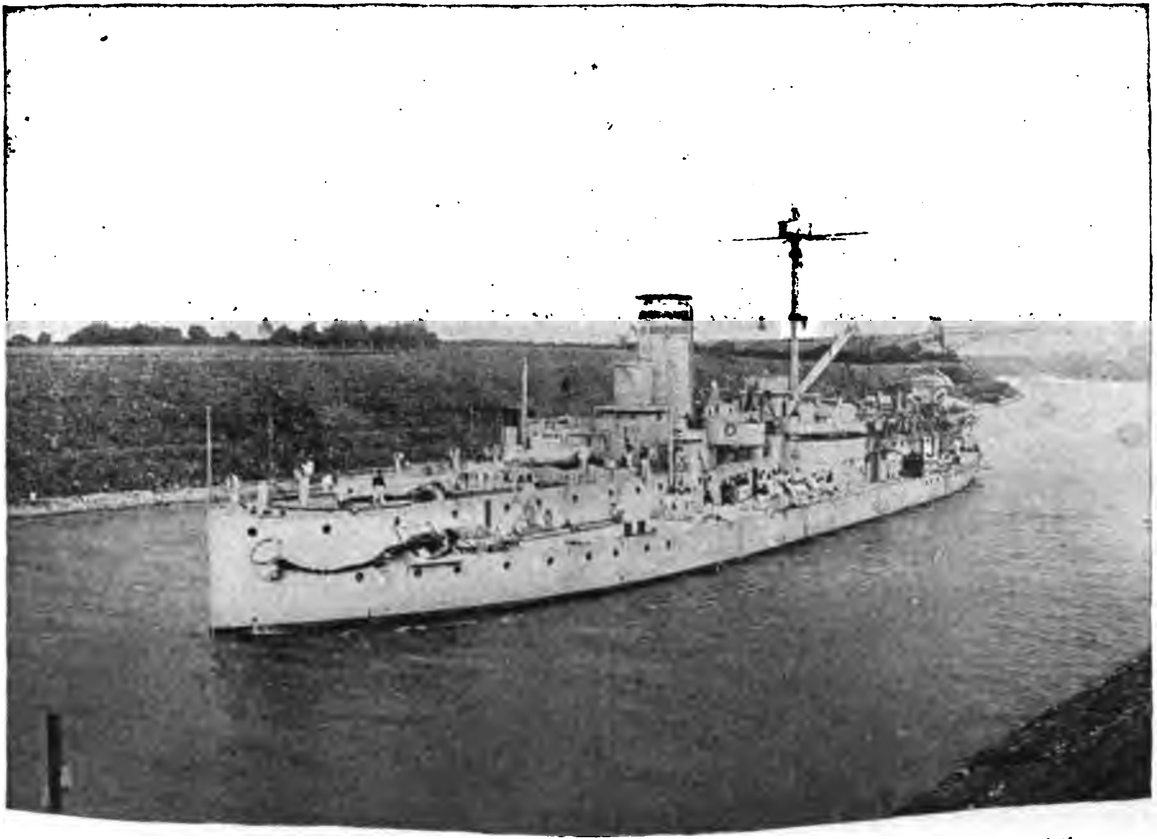
There are six search-lights, two in the fighting tops and four on the main deck. The complement of the *Kaiser Friedrich III* is 642 men.

—*Mittheilungen aus dem Gebiete des Seewesens*, 11, 1899.

Germany.



German Torpedo-Boat *S.* 85. *Mitth. Geb. des Seewesens*, VII.

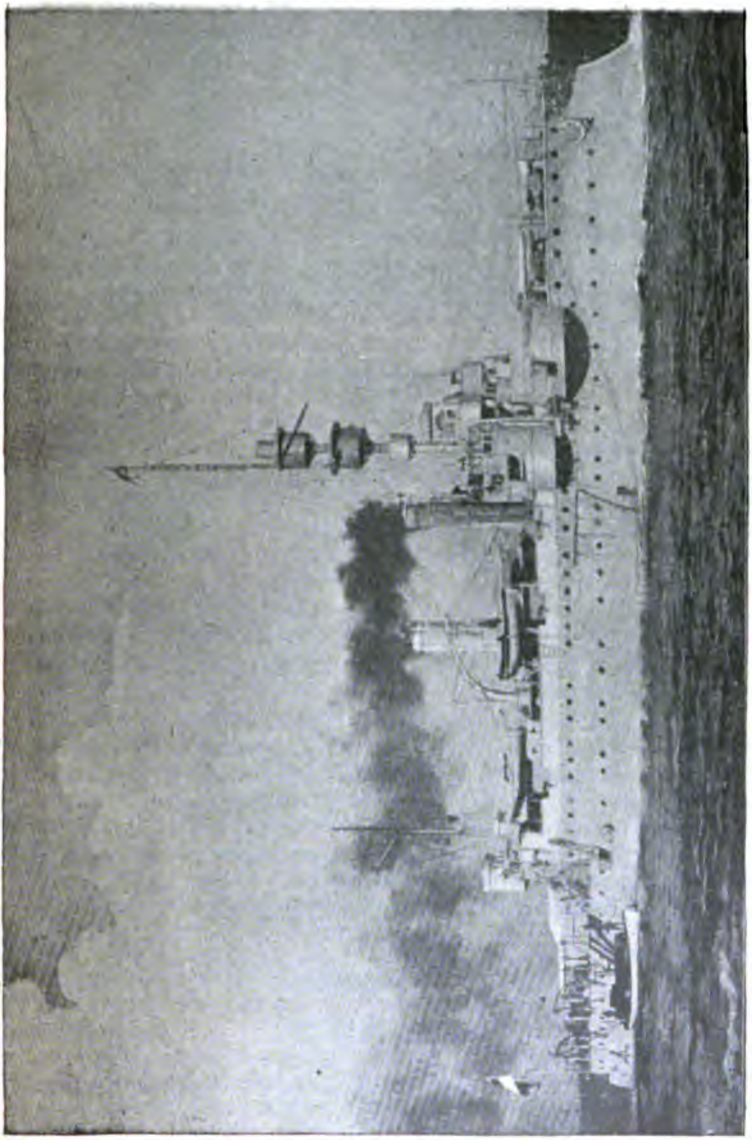


Rivista Marittima.

German Second Class Battleship Bayern.

The German torpedo boat *S* 85, one of the six new vessels constructed last year at the Schichau Works, is 158 feet long, 16 feet 9 inches beam, 9 feet draught aft, 155 tons displacement, and has a vertical triple-expansion engine of 1800 indicate horse power, and Thornycroft boilers, with a maximum speed of 25 knots. This torpedo boat, during the naval maneuvers on the 31st of August, 1898, sank in a heavy sea near the island of Fehmarn, but was afterwards raised again.

—*Mittheilungen aus dem Gebiete des Seewesens*, VII, 1899.



German Coast Defence Vessel *Hagen*.

Mitth. Geb. des Seewesens.

The armored coast defence ship *Hagen* is the last of six sister ships, which were built at the beginning of the nineties, the *Hagen* and the *Heimdall* have Harvey steel armor, and are therefore superior to their sister ships, the *Beowulf*, *Frithjof*, *Hildebrand and Siegfried.* The principal dimensions of these ships are 223 feet in length, 49 feet beam, 17½ feet draught and 3495 tons displacement. The *Hagen* has three 24 cm. (9.45 inch) guns, two forward in an oval barbette turret, projecting over the side, and one behind a barbette turret aft. The turrets have 8 inch armor. The auxiliary armament consists of eight 8.8 cm. (3.45 inch) rapid-fire guns and twelve mitrailleuses, with one under-water and three over-water torpedo tubes. The girdle armor is 9½ inch thick. In her trial trip the *Hagen* made over 14 knots with 4516 indicated horse-power.

—*Mittheilungen aus dem Gebiete des Seewesens*, VIII, 1898.

VESSELS RECONSTRUCTED.

The third-class battleships *Baden*, *Bayern*, *Sachsen*, and *Wurtemberg* have been extensively overhauled and remodeled; screws, boilers, and engines renewed, and the armament modernized, though the six 26 centimeter guns are retained. The woodwork has been removed and replaced by metal. The weight has been lightened by 300 tons. One large funnel, instead of four; one military mast. New conning tower forward, protected by hardened nickel.

The *Baden* was rebuilt by the Germania Works, Kiel.

The *Bayern* was rebuilt by Schichau, Danzig.

The *Sachsen* was rebuilt by the Imperial Works, Kiel.

The *Wurtemberg* was rebuilt at Wilhelmshaven.

The trial results after remodeling are as follows:

Baden.—April 15, 1898; 17 knots with 6,000 I. H. P,, and 17.3 knots with 6,200 I. H. P.

Bayern.—In the fall of 1898; 15.5 knots with 6,386 I. H. P.

Sachsen.—May 1, 1897; 14.5 knots with 5,940 I. H. P.

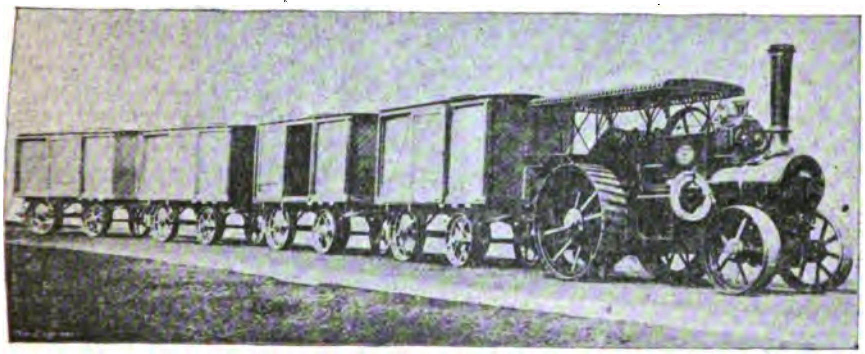
The armored coast-defense vessel *Hagen* is undergoing a modification which is probably entirely new in the art of naval construction. The imperial marine office intends to lengthen the *Hagen* considerably, although she has an armor belt of 24 centimeter thickness. The space thus gained is to be utilized for enlarging the coal bunkers, thereby giving the vessel a greater radius of action. Hitherto the coal supply amounted to 250 tons, permitting the vessel to steam 2,000 miles. The length of the *Hagen*, which is now 73 meters, is to be 80 meters after the reconstruction. At the same time the rapid-fire armament is to be increased, so that the fighting efficiency of the armorclad will be materially heightened by these modifications.

—*Notes on Naval Progress*, November, 1899.

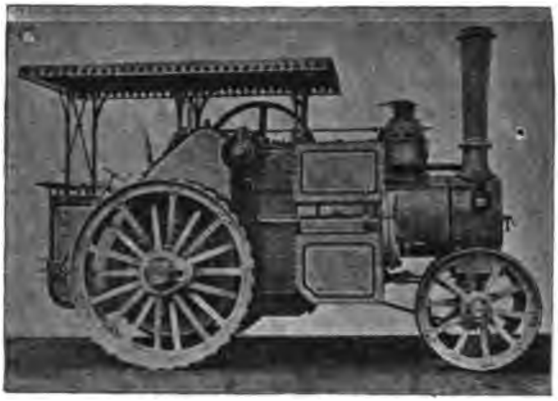
MISCELLANEOUS.

Traction Engines in War.

Traction engines have been used for military purposes at Chatham for many years; but until quite recently they have not been used by British authorities to any considerable extent in the field. Latterly they have been found very useful in the autumn maneuvres, and they are now about to be tried on a large scale in the Transvaal campaign, as already mentioned in our columns. There is no doubt that the traction engine for military purposes has an important future before it, and the photographs which we reproduce may be taken to represent the latest ideas of experts for this particular class of work. The engines and vans have been manufactured by J. and H. McLaren, of Leeds, to the requirements of the War-office. These engines have cylinders 7 inches and 11 inches diameter; they have developed as much as 70-horse power on the brake; and in actual test hauled a load of 55 tons up an incline of 1 in 12. They are exactly similar to those which the same firm has been supplying for some years to the Johannesburg district for use in hauling material to and from the mines. The engines are on the compound principle, and are provided with an extra allowance of fire-box and grate area, so as to burn the inferior fuel which is available in that district. The water tanks are also of a very large capacity, so that the engine will haul its full load for a distance of twelve miles on bad roads without the necessity for refilling the tanks with water. The crank shaft and all the other shafts are of extra strength and bearing surface, and the wheels are of extra width, so as to travel over soft ground without sinking. The steerage of the front wheels is effected by an arrangement of worm and rack, so as to be positive in its action, and without the backlash inevitable with chain steerage. This renders it much more reliable in travelling along roads which are frequently mere shelves on mountain sides, and where an accident to the steering gear might involve the most serious consequences. The engine is mounted before and behind on laminated locomotive springs, as are nearly all McLaren's engines. Notwithstanding the hundreds of engines at work with springs of this kind, in no single instance has a failure of the springs been reported. The engine illustrated is arranged so as to be fitted with a 7-ton crane in front. This crane, which is not shown in the photograph, can be attached or detached in a very few minutes, as, in order to dismount it, it is only necessary to remove four bolts—two in the back stays and two at the bottom of the jib, which is fixed on the smoke-box. The utility of this crane in the field was demonstrated the other day at Aldershot in the presence of the Duke of Connaught, when the engine lifted one of the field vans with the crane, and carried it about from one place to another, and later on lifted a traction engine, smaller than itself, bodily, and placed it on one of the traction wagons. The crane is worked by means of a worm and wheel, so that the load is sustained without any difficulty while the engine is moving from place to place.



Traction Engine and Military Train.



Military Traction Engine.

Mr. W. A. McLaren, who is a younger brother of the two well-known members of the Leeds firm, has been engaged by the War Department to serve under Colonel Templer, the military director of Traction Engine Transport in South Africa, and sailed in the transport Buluwayo last Thursday. We understand that he has had sixteen years' practical experience in pinoeer work with traction engines in the Colonies, and there is no doubt his experience will be valuable to the department in its first attempt to utilize traction engines in active service. Many of the improvements in McLaren's engines for adapting them for Colonial requirements are the result of his recommendation, and the fact that he used one of these engines for wood cartage in New Zealand, which has travelled nearly 70,000 miles without a crack in the fire-box, or breaking a spring, would appear to show that they have succeeded in adapting the engine to the tasks it has to perform. The result of this latest experiment of the War-office will be watched with great interest by engineers and military men in all parts of the world.

– *The Engineer*, November 24, 1899.

BOOK REVIEWS.

Historischer Rueckblick auf die Verpflegung der Armeen im Felde. Oberst Otto Meixner. III Lieferung. 1900. Vienna: L. W. Seidel & Sohn.

The third part of this excellent historical study on the supply of armies in the field treats of the Campaign of 1866 from the Austrian side. The author has, after a careful study of the great mass of literature on the campaign in general, condensed the information relating to the subject embodied in his work, namely *supply*, into about 127 printed pages, which are full of interesting information.

The subject is treated under three sections: Austria's war against Prussia, the Battle of Custozza and the Operations in South Tyrol. The principal part is devoted to the great campaign in the north, where the question of supply was rendered especially difficult by the rapidly changing operations and fields of action. The Battle of Custozza was so well conducted and so energetically executed that the system of supply serves as an interesting contrast to that of the campaign in Bohemia, while the operations in the Tyrol are valuable as illustrating the solution of supply problems in mountainous country.

The author's mode of treatment of the subject is such as to present the facts regarding supply in their relation to the general operations. The theater of operations, its yield in food articles, its communications, etc., is first described; then follows an outline of the organization of the army in the field, the relation of the supply department to the higher commands, the personnel of the supply department, and the organization and composition of the train; finally, the system of supply is discussed in detail,—the method of making requisitions, the duty of the supply detachments, the manner of keeping up the supply at the front, and the organization of the larger magazines and of the depots along the lines of communication. The author then takes up his subject proper: the mode of supply at the opening of the war, and the manner in which the supply was kept up in following the operations of the army.

We can best illustrate the manner of treatment of this last portion of the work, by quoting a few extracts:

"A glance at the movements of the Corps, as indicated in our sketch, from their successive arrival on the Elbe, beginning on the 26th of June, will show that they took place in an area which had its greatest breadth from Nachod to Miletin and its greatest depth from Trautenau to Königgrätz. each about 25 miles, and yet in this limited space the corps were almost constantly in motion; instead of an actual deployment of the army, or a definite military operation, there was a constant shifting of the positions of the corps.

"This peculiarity of the operations up to the Battle of Königgrätz is one of the causes explaining why the supplies, which had been so abundantly provided did not serve their purpose.

"In consequence of the immense accumulations of supplies the army supply train often stood still for hours on the crowded main roads or on bad field roads; again, they were moved off in one direction, soon to return to their former position, but only to find this occupied by other trains, till finally they were compelled to camp in the positions which had been designated for other subdivisions.

"The supply-column of the VI corps, for example, which had been directed from Skalic torwards Jaromei on the 28th of June, was compelled to pass the night on the road on account of the blocking up of the road by troops and trains of other corps. On the 29th it continued its march over Jaromei, Dubenec to Lancow, rested on the road till 5 p. m., again resumed its march, and reached its camp at Smiric between 11 p. m. and 3 a. m.

"The X corps, after the battles of Neu-Rognitz and Königinhof, reached its camp at Stern on the 29th of June, completely exhausted and without rations. The supply train of the corps stood only a few miles from Josefstadt, but it was impossible to get anything through.

"The repeated efforts to furnish the troops which had been engaged their needed supplies by means of small wagon parties, generally failed. Fifteen wagons, loaded with supplies, which had been sent after the VI corps over Skalic on June 27th, had to be destroyed on account of the desertion of the drivers. The bread supply for the X corps for June 28th was pushed forward to Trautenau on the afternoon of the 27th ; but by the events of the 28th only part of the troops received their bread rations, moreover, the 26 wagons carrying the supplies for the VI corps, for the 3d and 4th of July, and which were to have reached the corps on the 3d, although started betimes in the moving toward Opatowic, never reached the corps.

"These examples will suffice to show that at the time the corps are striving for a united tactical action, and are confined to a narrow area, their lines can no longer be penetrated by the larger trains, and even with small trains it will be very difficult to get through, consequently in this phase of the operations the necessary supply can only be furnished by such means as are immediately on hand in the subdivisions of the troops themselves, supplemented, as a matter of course, by such resources as the locality may have available."

The entire work is replete with lessons of this kind, and constitutes a very valuable study for all officers of the supply departments, and a knowledge of its contents is essential ror all who aspire to higher command.

J. P. W

Betrachtungen uber die Zukunft des mechanischen Zuges fur den Transport auf Landstrassen, hauptsaechlich uber seine Verwendbarkeit im Kriege. Olfried Layritz, Oberstleutnant Z. D. Pp. 85, with 20 illustrations. Berlin : E. S. Mittler und Sohn. Marks 1.75, about $0.50.

The subject of mechanical draft has been before the world for a number of years, indeed the traction engine preceded the railroad, and was partially developed in England in the early part of the nineteenth century, but the destruction of the roads and bridges by the heavy engines and vehicles of those days caused the public to turn its attention to the construction of special roads (railroads), and the sudden development of the latter caused the traction engine for ordinary roads or level country without rails to be forgotten. Soon after the middle of the century the demand for portable engines in agriculture caused the re-introduction of traction engines.

The first military application of the traction engine was in the Crimean War, but the long interval of peace succeeding that war caused it to be neglected, although its development in agriculture continued. The more recent experiments with traction engines for military use date from 1875 in

France and 1876 in Russia, and in the Turko-Russia War of 1877-8 they were used to some extent, especially for the transportation of artillery material, ammunition and supplies between the parks or stations and the army front.

The latest experiments with traction engines were at the English maneuvers in 1898, and they are now being used practically in the Boer War.

The author discusses this interesting subject in an intelligent manner, his purpose being to show what has been done and along what lines future improvements and applicantions will probably take place. The pamphlet is well illustrated, and gives a very complete and accurate idea of the present state of the question of traction engines, including some discussion of automobiles and their uses for military purposes, and is well worthy of careful study by all officers, as the subject is one of paramount interest in connection with the all-important matter of supplies and ammunition at the front.

J. P. W.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

Schiffbau, Central-Organ für Werft und Rhederei. Ansbaeherstrasse 14, Berlin (W.), Germany.

A new periodical with the above title appeared last year, and appears to have been well received. It is published on the 5th and 20th of each month, and treats of the engineering problems connected with ship-building.

The contents of the latest number received (December 20) will give some idea of its purpose and scope :

The Turbine as a ship-propelling machine. H. Sellentin, marine engineer.
The Electrical propulsion of torpedo boats. H. Michel, electrical engineer.
The ships built by the Dantzig Works.
The *Columbia* and the *Shamrock*, von Süssenguth, naval constructor.
Meeting of the Ship-builders Association.
German and Foreign navies.
Current naval literature.
Patents.
Ship-building Works.
Miscellaneous.

The Internationale Revue appears in a new dress at the opening of the year 1900. It now consists of the regular monthly number, an occasional supplement in German (*Beiheft*) and a monthly *Supplément* in French.

The regular monthly numbers will hereafter publish authentic notes on the military developments of the different states. Thus, the first number of the new year has such notes on Argentina, Belgium, Germany, Egypt, France, Great Britain, Italy, Japan, Norway, Orange Free State, Russia, Sweden, Servia, Transvaal Republic, United States, General.

The larger articles of special interest will appear in the *Beiheft*, and the French supplement is intended to furnish information in regard to military developments in Germany to such as cannot read German fluently.

The Engineering Magazine, February, 1900. 120-122 Liberty street, New York. 30 cents, $3.00 a year.

We desire to call attention to *The Engineering Index* in this number, most excellent in itself, and made extremely useful to all interested in engineering and industrial pursuits by the publishers furnishing the full text of every article indexed for a small sum.

Ed.

Organ der Militär-Wissenschaftlichen Vereine. Volume LIX. No. 5. 1899. We desire to call attention to the excellent index to current military literature contained in this number.

The Autumn Maneuvers of 1898. War Department, Adjutant General's Office, August, 1899. No. XXVI.

Report of the Adjutant-General of the Commonwealth of Virginia for the years 1898 and 1899. Richmond, Va.

Exercises in Descriptive Geometry. Arranged by 1st Lieutenant G. Blakely, 2nd Artillery. Department of Mathematics, West Point, N. Y. 1899.

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INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

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Aldershot. Copies 6d each.

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Effingham House, Arundel Street, Strand, London, W. C. Per year 7 s.

Army and Navy Gazette. [*A. and N. Gaz.*] *Weekly.*
3 *York Street, Covent Garden, London. Per year £*1 12*s* 6*d.*

Canadian Military Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year £*2 6*d.*

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22 *Charing Cross, Whitehall, London, S. W. Per year* 24 *s.*

Journal of the United Service Institution of India. [*Jour. U. S. I. India*]
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Photographic Journal. [*Photo. Jour.*] *Monthly.*
66 *Russell Square, London.*

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25 *Great George Street, Westminister, London.*

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[*Proceedings I. M. E.*] 19 *Victoria Street, Westminister, London.*

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Professional Papers of the Corps of Royal Engineers.
[*Prof. Papers Corps Royal Eng'rs.*]
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169 *Queen Street, Melbourne, Australia. Per year* 11 s. 6 d.

Transactions of the Canadian Institute. [*Trans. Canadian Inst.*]
58 *Richmond Street, Toronto, Canada.*

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51 *Hanover Street, Edinburgh, Scotland.*

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5 *Adelphi Terrace, London, W.C.*

United Service Gazette. [*U. S. Gaz.*] *Weekly.*
10, *Wine Office Court, Fleet Street, London, E. C. Per year* £1 10 *s* 6 *d.*

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3 *Place du Théatre Français, Paris, France.*

Le Génie Civil. [*Génie C.*] *Weekly.*
6 *Rue de la Chaussée d'Antin, Paris. Per year* 45 *Fr.*

La Marine Française. [*Marine F.*] *Semi-monthly.*
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438 *Alsina, Buenos Aires, Argentina Republica. Per year* $11.00.

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New York City. Per year $2.50.

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293 *Broadway, New York City. Per year* $3.50.

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26 *Cortlandt Street, New York City. Per year* $5.00.

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Vol. XIII. No. 3. Whole No. 43.

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JOURNAL
OF THE
UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

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ARTILLERY SCHOOL PRESS,
FORT MONROE, VIRGINIA.

ENTERED AT THE POST OFFICE AT FORTRESS MONROE, VA., AS SECOND CLASS MATTER.

UNITED STATES ARTILLERY SCHOOL,

FORT MONROE, VIRGINIA.

The *Journal of the U. S. Artillery* is published at the Artillery School as a bi-monthly, by authority of the Staff of the School

COMMITTEE OF DIRECTION AND PUBLICATION.

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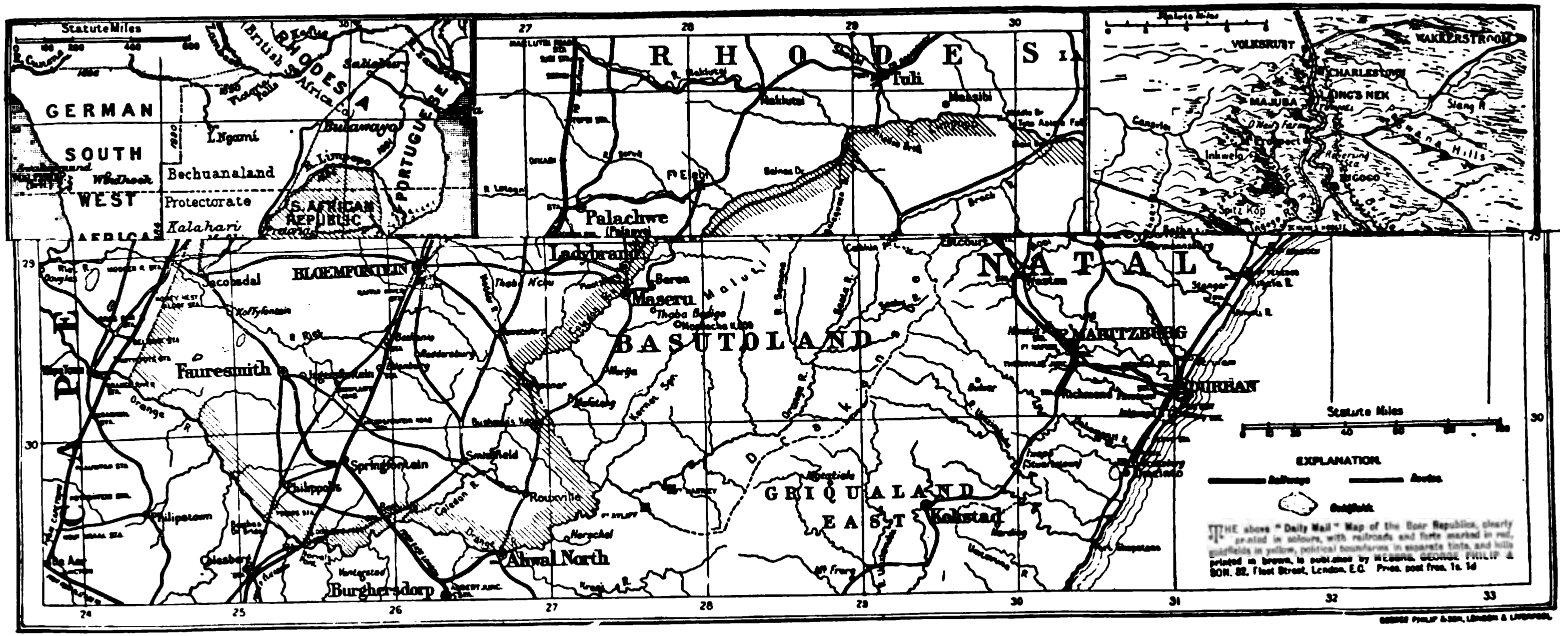
Subscription	$2.50
For countries in the postal union	$3.00
Single numbers	$0.50

Remittances should be sent to the editor at Fort Monroe, Va.

AGENTS.

NEW YORK—*Dyrsen & Pfeiffer*, successors to
F. W. Christern, 254 5th Avenue.
LONDON—*B. F. Stevens & Brown*, 4 Trafalgar Square.



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JOURNAL
OF THE
UNITED STATES ARTILLERY.

VOL. XIV. No. 3. MAY—JUNE 1900. WHOLE No. 43.

THE SECOND BOER WAR.*

INTRODUCTION.

The history of the South African Republic (formerly called the Transvaal Republic) and the Orange Free State begins with that of Cape Colony.

The Dutch East India Company, recognizing the importance of the Cape of Good Hope as a station where their vessels might take in water and provisions, formed a colony there in 1652. The colonists gradually drove the natives back, reduced them to slavery and introduced Malays and negroes as slaves. The Dutch government harassed the farmers, demanding a large part of their produce, and thus inspired the colonists with their dislike to interference by the home government, and a love of independence. In 1795 they attempted to throw off the yoke of the Dutch, when the British sent a fleet to support the authority of the Prince of Orange, and took possession of Cape Colony in his name, but as Holland was not able to hold it, the British ruled there until 1802, when, at the peace of Amiens, it was again restored to Holland. In 1806 it was again taken by the British, and was finally ceded to them in 1815.

The Boers ill-treated the natives to such an extent that they were often in danger of extermination, and Great Britain had to protect them.

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* The account here given was derived from a careful study of the following exchanges of the *Journal U. S. Artillery*, (to which were added from time to time such original thoughts on organization, tactics and strategy as suggested themselves), viz: *Internationale Revue*, *United Service Gazette*, *Revue du Cercle Militaire*, *Militär-Wochenblatt*, *Army and Navy Gazette*, *Deutsche Heeres-Zeitung*, *Schweizerische Militärische Blätter*, *Allgemeine Schweizerische Militär-zeitung*, *Armée et Marine*, *Mittheilungen über Gegenstände des Artillerie und Genie-Wesens*, *Umschau*. etc.

By a succession of wars with the natives, or Kaffirs, the boundary was gradually extended. The first of these wars took place in 1811–12, the second in 1819. In 1820, British emigrants laid the foundation of the settlements around Port Elizabeth, and in 1834 the slave-emancipation measure took effect in Cape Colony, and this gave great offense to the Dutch Boers, who were large slave owners. In 1835 the third Kaffir war took place, and not long after that the Boers resolved to free themselves from the British government (which began to enforce measures to protect the natives against Boer injustice) and removed beyond the Orange River, a portion also crossing the Drakenberg mountains into Natal, establishing in both places republican governments, which they maintained till 1842, when the British extended their authority into Natal, and the Boer colony there passed again under British rule. The Boers had so incensed the natives that the peace of the whole country was menaced, and interference became necessary. The fourth Kaffir war occurred in 1846-8.

The Boers beyond the Orange River maintained their independence till 1848, when, at the solicitation of the Boer authorities (in consequence of the lawless state of the country) the British annexed the country under the name of the Orange River Sovereignty. Not long after, the Boers of Natal crossed the mountains, joined some of the disaffected Orange Boers and raised the standard of rebellion. A detachment of British troops met and defeated them, and a number retreated over the Vaal river and established a government of their own, first called Trans-Vaal, which was afterwards recognized by the British in 1852, and then called the South African Republic.

The fifth Kaffir war was conducted between 1850 and 1853, and by it British Kaffraria was formed into a separate colony. In 1853-4 the Orange Free State was formed, with the consent of England.

The discovery of diamonds in the districts north of the Orange River in 1867 led in 1874 to the annexation by the British of Griqua Land West, in 1881 of Basuto Land, and in 1885 of Bechuana Land. Later, Cecil Rhodes, manager of the South African Chartered Company succeeded in adding Mashona and Matabele Land, and finally Barotseland.

In 1877, in consequence of Boer trouble with the natives, an empty treasury, and general discouragement due to repeated reverses in the contests with the natives, England intervened and annexed the Transvaal. In 1879 England fought the Zulu war to protect the Transvaal and the Boers.

In 1881, after the revolt of the disaffected Boers and the defeat of the English at Majuba Hill in 1880, the republic was restored under the suzerainty of England, but this was so far modified in 1884 as to render the South African Republic practically independent.

The discovery of rich gold deposits in 1886 led to a great influx of British subjects, and difficulties arose from the attempts of the Boer government to enforce military service on them, though they were debarred from franchise. The tension grew stronger as the number of foreign gold seekers (Uitlanders) increased, and the latter began to ally themselves with Cecil Rhodes, with Chamberlain, the Colonial minister, and with other influential Englishmen. This finally led in 1896 to an attack by Doctor Jameson and 500 men of the Chartered Company on Mafeking, with the intention of moving on Johannesberg, but he was met at Krugersdorp and repulsed by the Boers, under Cronje, who killed a number of his force and sent the rest for trial to England.

In 1897 the Uitlanders amounted to 180,000, and possessed 63 per cent. of the landed, and 90 per cent. of the personal property in the country.

In April, 1899, a petition signed by 11,000 Englishmen living in Johannesberg was transmitted by Greene, the British agent at Pretoria, to Sir Alfred Milner, governor of Cape Colony, and by him forwarded to the Queen. The petition set forth the fact that they were debarred from franchise, and complained of the dynamite monopoly. Krüger promised reforms in the franchise, and fixed upon 9 years as the term of residence required to obtain the right to vote, instead of 14, previously established. The discontent, however, continued. Steyn (the President of the Orange River Free State) then proposed the Blomfontein conference. Milner demanded 5 years as the term for naturalization, but Krüger would only compromise, and proposed 7, but without any retroactive effect. Milner then broke off the conference. The Orange Free State then intervened and persuaded the Volksraad in Pretoria to grant also the retroactive effect of the 7 year naturalization law, and to give four new seats in the lower house to the Uitlanders.

Now, complaints about the police, the language taught in the schools, and organization laws began to be made, and Chamberlain began to make inquiries as to the suzerainty of England and to express a desire for a mixed Commission in Cape Colony, a proposal which was interpreted to aim at the Independence of the Republic.

Upon this Krüger proposed to grant the 5 year naturalization law, with retroactive effect, and 10 seats in the lower house, provided England gives up all claim to suzerainty. The British government would not consider the last point at all, and on the 12th of September Chamberlain, through the British representative in Pretoria, Conyngham Greene, submitted as a fundamental condition for the proposed conference: 5 years naturalization, one-quarter of the seats for the Uitlanders, and equality of Boers and Englishmen in the Volksraad and in the election of President. On the 14th both Volkraads decided on the 7 year naturalization law, and demanded as a basis for the conference the convention of 1884.

The situation was critical. Early in September England had ordered 5,000 troops in India, and an equal number from European stations to hold themselves in readiness, to proceed to Africa, and towards the end of September these troops actually sailed from Calcutta and Bombay for Natal. The two Boer states also began their war preparations, and by the end of September there were 13,000 armed men on the Natal frontier, 1,500 in Boshof near Kimberley, and 4,000 near Malmain, opposite Mafeking.

On the 9th of October, 1899, Mr. Conyngham Greene, the diplomatic representative of Great Britain at Pretoria, received the ultimatum of the Transvaal Republic. It stated that if in 48 hours the British troops did not retire from the border, war existed, and demanded also that the reinforcements already landed, as well as those on the way be sent back. It reached the Colonial Office in London on the 10th, and on the 11th the British government replied that the conditions imposed by the Transvaal were such that the British government could no longer discuss the subject. On that day Mr. Conyngham Greene left Pretoria, and at 5 P. M., the Transvaal was declared in a state of war, and the offensive movements of the Boers began. The Orange Free State, bound by a treaty of alliance, joined the Transvaal.

THE FORCES ENGAGED.

To understand the initial operations, it will first be necessary to obtain a clear conception of the positions and strengths of the respective armies at the opening of the campaign.

The English Troops.

The English forces for the Boer War are divided into three groups, viz: the troops in Natal, the troops in Cape Colony and the newly mobilized army corps to be sent to South Africa from England.

The Natal Force.—The Natal force, commanded by Symons, comprised

10 battalions of infantry	7650 men.
4 regiments of cavalry	1650 men.
6 field batteries and one mountain battery (42 guns)	1218 men.
4 companies of pioneers	600 men.
4 companies train	300 men.
Natal volunteers	760 men.
Natal Carabiniers	120 men.
Imperial Light Horse volunteers	500 men.
Durban volunteers	750 men.
Mounted Natal police (9 guns)	550 men.
Total, 51 guns	14,098 men.
Reinforcements arriving (from India) 3 field batteries (18 guns)	530 men.
Total for the first act in the drama, 69 guns,	14,628 men.

The Cape Colony Force.—The Cape Colony force, commanded by White, comprised

8 battalions of infantry	4090 men.
2 companies heavy artillery	200 men.
2 companies train	150 men.
Total	4440 men.
Reinforcements arriving (due October 29) 2 battalions infantry	700 men.
Total for the first act	5140 men.

There was no cavalry or artillery with this force. The strength of the volunteer forces on the western border of the Boer States cannot be accurately determined, but they are estimated at about 4,000 men. Besides these troops, the English squadron had also landed a naval brigade of about 1,000 men, which was to be sent to the western border of the Boer states.

The Army Corps.—The mobilized army corps, under General Sir Redvers Buller, war organized into 3 divisions (commanded respectively by Lord Methuen, Sir Clery and Sir Gatacre) and a cavalry division under French.

Its total strength was about 40,000 men, with 114 guns.

On the eleventh of October the British had in Glencoe camp (near Dundee) about 4,000 men, at Ladysmith about 9,000 men.

At Aliwal (on the southern border of Orange Free State) there was only a half regiment and 100 mounted infantry; further south a small reserve. In Kimberley (on the western border of Orange Free State)

4 half companies infantry	700 men.
Volunteers	1500 men.
Artillery	20 guns.

Mafeking (on the western border of the Transvaal Republic) had only 600 volunteers under Colonel Baden-Powell. There were also 400 volunteers opposite Tuli (on the northern border) under Colonel Plumer.

The Boer Troops.

The Boers had about 28,000 men under arms in the Transvaal (commanded by General Joubert), and about 14,000 regulars in the Orange Free State (under General Groebler), posted as follows:

At Sandspruit, Wakkerstrom and Volksrust, north of the wedge of Natal, under Joubert	12,000
On the Buffalo River opposite Vryheid, under Lucas Meyer	2,000
On the road to Dundee	1,000
In Zoutpansberg district (northern border)	2,000
At Komatiport (opposite Delagoa Bay)	2,000
Opposite Mafeking, on the western border	6,000
Reserve, in the interior	3,000
At Albertina Station and Vanreenens Pass (west of Ladysmith)	8,000
From Botha Pass to Bezuidenhouts (to watch the passes west of Ladysmith)	3,000
Opposite Kimberly (on the western border)	3,000

THE STRATEGIC POSITION.

The wedge of Natal, projecting as it does into the Boer country, would be advantageous were it properly occupied by a sufficient force, because it would give the British the great advantage of always operating on interior lines, but the superior force of the Boers enabled them to overcome this strategic advantage, and turn the British positions. The small British force on the western border was very dangerous, especially as it exposed the important railroad from Cape Town to Buluwayo.

In occupying their too *advanced* position at Glencoe the British were exposing their troops to disaster, for it is a maxim of war that "when a commander endeavors to cover too much he covers nothing." It would have been better to have concentrated further back, as at Ladysmith, and utilize the advantages of interior lines by falling upon the separate Boer columns in turn before they could unite.

THE OPERATIONS.

Preliminary Operations on the Western Border.

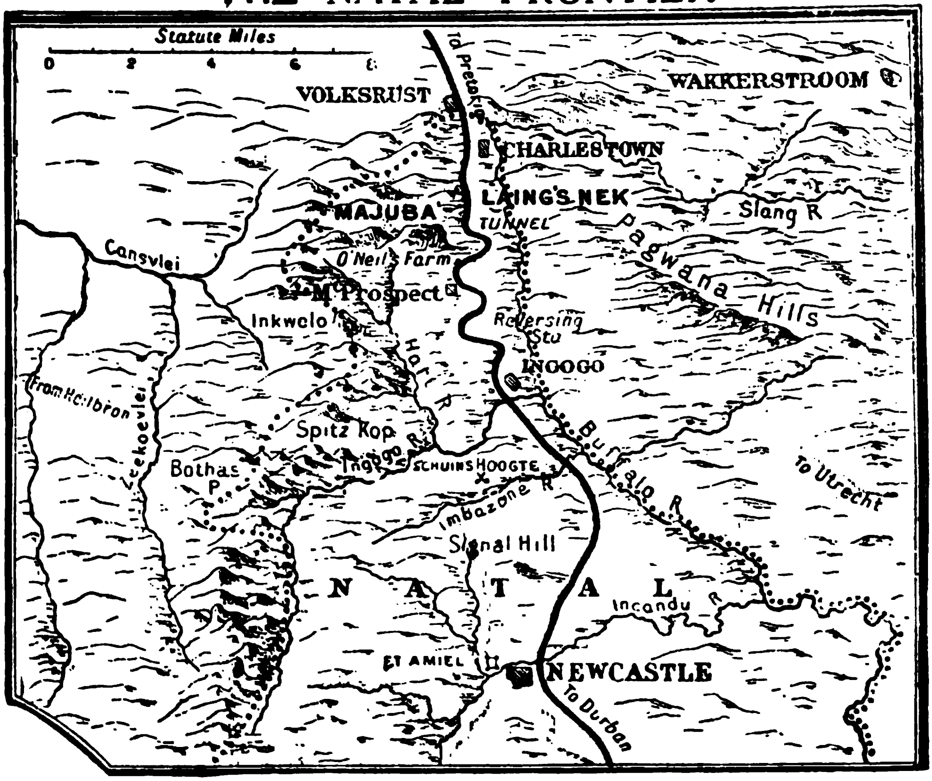
The object of these operations on the part of the Boers was to isolate the two important towns of Kimberley and Mafeking, and to prevent invasion of their territory; and on the part of the British to gather supplies preparatory to siege, and to check further advances of the Boers beyond the Orange River.

On the 12th of October the Transvaal Boers, under Cronje, advanced in two columns on Mafeking, one (4,000 strong) from the Lichtenburg district, crossing the border at Maritsani, south of Mafeking—500 men of this column attacked and captured, at the station Kraaipan, an armored train which was repairing the telegraph line north of Vryburg and carrying ammunition to Mafeking—; the other column from Zeerust and the Marico valley, threatening Mafeking from the north. On the 13th Cronje's troops destroyed the railroad and the railroad bridge over the Molopo River, 8½ miles north of Mafeking. On the 14th all rolling material and stores in the vicinity were sent to Kimberley. On the 14th the Boers occupied Ramathlabama, north of Mafeking. Soon after, the railroad and bridge at Modder River Station were destroyed by the Boers. On the 16th the Boers took possession of the railroad north and south of Kimberley, and a Boer commando from Bethulie moved towards Norvals Pont and destroyed the railroad. On the same day another Boer force occupied Taungs. On the 17th the Boers destroyed the bridge over the Vaal at Fourteen Streams station. On the same day the British destroyed the railroad bridge at Hopetown. On the 18th the Boers destroyed the railroad north and south of Kimberley. While these preparatory measures were being taken on the western border, the principal campaign was going on in the east, in Natal.

Operations in Natal.

On the night of October 11–12 the Boers advanced in several columns: one from Sandstruit, on the road, to Laings Nek, occupying with artillery the defile of the railroad to Newcastle; another from Wakkerstrom south through the Belebas hills to the Buffalo river, occupying its bridges; a third marched from Utrecht on the road towards Glencoe; a fourth from Doornberg

THE NATAL FRONTIER

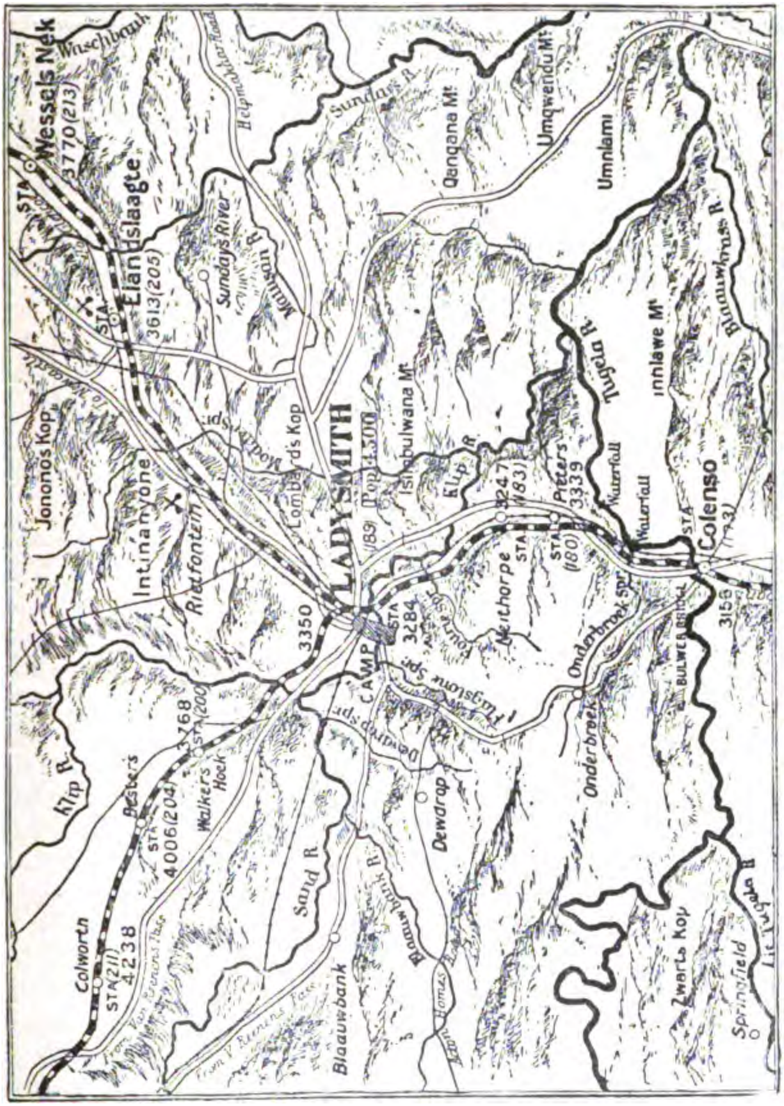


to Rorkes Drift, occupying the cross-roads leading to Glencoe and Ladysmith opposite Washbank and Wessels Nek stations; a fifth marched to the right of Majuba Hill along the border to Botha Pass; a sixth from Vrede to the Müller Pass; and the Orange Boers (with ox train and 11 guns) from Albertina and Harrysmith in three columns to Van Reenens Pass, Tintwa Pass and Bezuidenhout Pass.

By midnight of the 12th all the passes on the eastern and western borders of Natal were in the hands of the Boers, and on the 13th the British abandoned this district to within six miles of Glencoe and Dundee.

At 3 a. m., October 13th, General White (then commanding at Ladysmith) advanced on the road towards Acton Homes to attack the Boers and prevent the junction of the columns from the passes, but the column from the Tintwa Pass (under Major Albrecht) took him in flank and forced him to retire, while General Groebler from Van Reenens Pass threatened to cut him off from Ladysmith. The Boers followed the retiring British and occupied positions commanding Ladysmith.

BIRD'S-EYE VIEW OF LADYSMITH AND ENVIRONS.



In the north the columns united at Ingangane, near Königsberg, and pushed outposts out to Glencoe on the evening of the

13th. They then set to work to intrench themselves, awaiting the advance of the left wing. The British ordered the garrisons of Pietermaritzburg and Durban to work day and night to put these points in a state of defence.

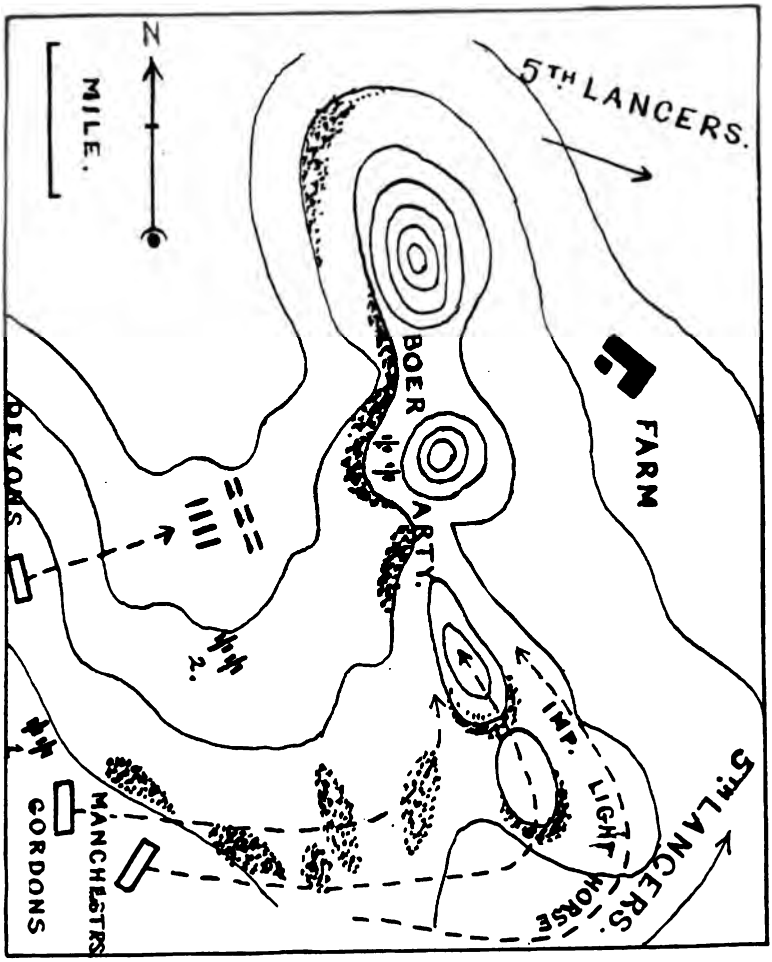
By October 15th the Boers had 1,500 men in Newcastle, with 10 light and 2 heavy guns; these troops were under Viljoen. On the 16th the main body of the Boers was at Ingagani, and on the 18th Joubert made his headquarters at Dannhauser. On the 19th the latter marched towards the Impati Hill, while Lukas Meyer, commanding the columns from Wakkerstrom and Utrecht (4,000), was ordered to attack from the east. During the night he succeded in getting 6 heavy guns on Dundee Hill, and at 5.30 a. m. opened the attack.

The advance of the Boers is open to the criticism that in subdividing into so many columns they exposed themselves to the danger of being separately attacked and destroyed before they could reunite, but in all probability the explanation of their action lies in the fact that this subdivision was forced upon them by the nature of the country and the character of the roads.

By October 20th the left wing of the Boers had arrived in position, and the strategical movements of the Boers were completed, and the tactical operations began.

The occupation of Dundee Hill (between the Glencoe—Newcastle railroad and the Glencoe—Dundee branch) by the Boers on the 20th led General Symons to attempt to dislodge them with portions of two regiments supported by 20 rapid-fire guns, but he only succeeded in causing the withdrawal of the Boer artillery (6 guns). General Symons tried again and again to strike the enemy in flank, but failed, and at 9 A. M. he received the report that Dundee was also threatened by a Boer column of 9,000 men and a battery, under Joubert in person, coming from the direction of Hatting Spruit to the east of Dundee Hill. The position in which Glencoe would be placed by the advance of this column, unless Dundee Hill were taken, decided General Symons to make another advance in force. In this attack General Symons fell, mortally wounded, and General Yule succeeded to the command. At 1 p. m. the position was taken and the Boers retired. The British lost 12 officers and 33 men killed, 21 officers and 163 men wounded. The Boer loss is not known, but is given at 300 killed and wounded, their field hospital and entire train was taken by the British. Such was the battle of ***Dundee.*** A squadron of the 18th Hussars, sent in pursuit of the Boers after the battle lost 4 killed, 9 wounded and 86 captured.

While General Symons with all his force was thus struggling against the *advance guard* of the Boers, their main body was quietly advancing in the rear, cutting communication between Glencoe and Ladysmith, and completing the environment of both these places. General Schalk Burgher, with the column from Vryheid, closed in on Glencoe from the east, his left flanking column occupying Washbank; while General Viljoen, passing Glencoe on the west, pushed out his outposts to the Impati Hill; and Joubert's advance-guard under Jan Kock occupied the Biggars Hill, his forces reaching around to the right towards the Orange Boers, who were advancing towards the Pietermaritzburg railroad.



This situation forced the British to act, but it was a question whether to strike in a northerly direction to prevent the union of the column near Dundee with the main column farther west, or in a southerly direction to prevent that of the columns from east and west, now approaching each other at Elandslaagte.

On the 21st Yule attacked the Boers north of Glencoe and pushed them back, but when the column from Vryheid took part in the engagement he was forced to retire. Dundee and Glencoe were abandoned, and a position nearer Ladysmith taken up. This is the battle of *Glencoe*, although the action at Dundee is also called by that name.

At the same time General White decided to reopen communication with Glencoe by attacking the Boers at Elandslaagte. General French was sent out by rail with the advance guard at 4 a. m., but the main body under White did not arrive till 3.30 p. m., when the battle opened.

The Boers occupied two kopje, or heights, their principal camp being between these kopje in the saddle, the artillery being intrenched on the lower of the two heights. At about 4 p. m. the British artillery opened from a position 4,400 yards from the Boers and prepared the attack for the infantry. This artillery preparation was deemed sufficient in about half an hour, and General French decided to make the infantry attack, the artillery moving up to its second position at 2250 yards from the Boers, finally supporting the advance at 1950 yards.

The Devonshire regiment attacked in front, advancing over perfectly open ground. Three companies were deployed in first line on a front of 380 to 500 yards, furnishing their own supports. The other four companies remained in reserve in single file columns at 50 paces interval, the latter being increased when the Boer artillery opened on them.

When the regiment arrived at about 1,200 yards from the enemy's position, Major Park, commanding the first line, halted it and opened fire, the only protection for the men being low ant hills. The advance was continued, and, after a few volleys executed at a halt, the line was reinforced by the supports, and again advanced. In spite of the hail of bullets the line moved on without a break, unhesitatingly, to within 750 yards of the enemy, and there remained lying down for a full half hour, exposed to artillery and infantry fire, awaiting the signal for the final assault. Their khaki uniforms and the approaching darkness probably saved them from destruction.

Meanwhile a flank movement was executed by the Manchester regiment, which, after passing the guns, was joined by a dismounted squadron of Imperial Light Horse, the Gordon Highlanders following in support. The movement was over the low est of the chain of heights, turning the left flank of the Boers. On arriving at the foot of the hill a heavy storm broke forth, and when it was over the Gordon Highlanders found themselves among the rocks covering the crest of the hill, and exposed to the enemy's fire. The supports then entered the line, filling up the interval between the columns. A small plateau was then crossed, next a depression between the hills and finally a steep slope had to be scaled, but in spite of the difficulties and losses the line steadily advanced to within 600 yards of the enemy. The ground was entirely open, as regards trees, but covered with stones and wire entanglements. The colonel, Dick Cunyngham, of the Highlanders had been twice wounded, and half the officers were laid low, when Colonel Hamilton ordered a trumpeter to sound the charge, which was taken up by all the other trumpeters, and drum-major Lawrence jumped to the front and placed himself at the head of the line, playing the national air.

The entire line now advanced.

At 6.30 p. m. the Boers' position was taken, 2 of their guns being captured. The 5th Lancers were sent in pursuit. The Boers lost about 500, including General Koch and Colonel Schiel (commanding the German volunteers); the British lost 6 officers and 49 men killed, 29 officers and 178 men wounded, and 10 men missing. This is called the battle of *Elandslaagte.*

The communication with Yule was reestablished, and the latter, on the 23rd started to join forces with White, concentrating at Ladysmith.

Action at *Rietfontein.*

On that day (23rd) Yule reached Beith by the Helpmakaar road, and at 9.30 a. m. on the 24th was at Washbank Spruit; the column followed the valley of the Washbank and on the morning of the 25th reached that of the Sunday, and on the 26th entered Ladysmith.

General White, knowing of Yule's appaoach, moved out to Rietfontein on the 24th to cover his flank from attack. He had heard that a force of Orange Boers from Bester's Station had taken up a strong position west of the road Glencoe—Ladysmith.

His force consisted of about 4,500 men:

5th Lancers,
19th Hussars,
Imperial Light Horse,
Natal Volunteer Carabiniers,
Border Mounted Rifles,
Natal Mounted Rifles,
1st Battalion Gloucestershire Regiment,
1st " Liverpool "
1st " Devonshire "
2nd " King's Royal Rifles.
42nd and 53rd field batteries, 10th mountain battery.

He met the Boers (about 1,500 men) at Rietfontein, the advance guard of cavalry under French coming upon them at 7 a. m., and held them in check until noon, when, learning that General Yule had passed through the defiles of the Biggarsberg, he retired to Ladysmith. British loss 116, Boers 230.

The Boers closed in on Ladysmith and cut the Ladysmith-Pietermaritzburg railroad at Colenso. Their concentric advance, in spite of the disadvantages they experienced after crossing the mountains in so many columns, succeeded. The Boers were *forced* to subdivide their forces by the difficult country they passed through, but the same excuse cannot be applied to the British. The probable reason for their dividing into two forces (Glencoe–Dundee and Ladysmith) instead of concentrating at some point as at Ladysmith, was the fact that Glencoe threatened a Boer advance on the main road over Newcastle, Dundee possesses important coal fields, and Ladysmith covers the very important line to Pietermaritz.

Meanwhile, another important movement has taken place. A Boer column has started from Fort Evelin (the southernmost point of the Transvaal and is marching along the Ummula River over Melmoth to the coast, evidently with a view to influencing the Zulus to take an active part against the English.

Operations on Western and Southern Border.

In the west and south of the Boer Republics the strategic deployment and advance progressed more slowly. At the opening of the war there were about 2,000 Boers along the Bechuana railroad, and by October 14th Cronje had 6,000 men opposite Mafeking, which was garrisoned by about 600 colonial troops under Colenel Baden-Powell. At Kimberley there was a garrison of about 2,500 men, under Colonel Kekewich, half of which were British troops, with a considerable number of guns: on October 15th the Orange Boers under Botha besieged it.

On October 15th took place an action near *Mafeking*, in which the Boers were repulsed. The British lost 2 killed and 15 wounded; the Boers 53 killed and many wounded.

On October 24th a small, but important engagement took place north of Kimberley, in which 500 British attacked and defeated 700 Boers: General Botha was among the killed. The British lost 3 killed and 21 wounded. A sharp skirmish also took place at *Rhodes Drift*, near Tuli. On the same day the Boers occupied Klipdam in Griqualand-West, and on the 25th they occupied Vryburg and Barkly West. On the latter day the Boers made a determined attack on Mafeking but were repulsed with considerable loss. Colonel Baden-Powell had a railroad track laid encircling the town, and armored trains were placed in operation on it, and could be taken quickly to any threatered point.

The Boers are masters of the situation on the western border, and the occupation of points like Taungs, 40 miles south of Vryburg, has enabled them to isolate the English at Mafeking and Kimberley. On the southern border they have occupied Aliwal North and the bridge over the Orange River, with outposts at Burgersdorp, threatening the railroad junction at de Aar.

Summary and Review.

Let us review briefly the progress of events up to the end of October, which marks the end of the first act and the beginning of the second.

At midnight on October 11–12 General Joubert directed all the Transvaal and Orange Boers under his orders to break camp, and by noon the next day their concentric march on the British position, Dundee—Glencoe—Ladysmith, was well under way. The plan of campaign of the Boers was strategically sound, and its practical execution in detail was tactically correct in the main, all the circumstances being carefully considered. Among the tactical measures, to ensure the safety of the general movement, may be mentioned (1) the sending out beforehand the advance guard of the Sandspruit corps from Volksrust to Laingsnek and occupying this position and the railroad defile to Newcastle before daybreak; (2) the movement of the Wakkerstrom corps in the general direction of Newcastle, and occupying the bridges over the Buffalo river; (3) the Dornberg corps taking up a position at Vants Drift opposite Rorkes Drift as early as the 11th, so as to be able to reach the cross-roads to Glencoe and Ladysmith opposite Washbank and Wesselsnek on the 12th; (4) the advance on the same day of the Utrecht and Vryheid commands to De Jägers Drift on the Glencoe road.

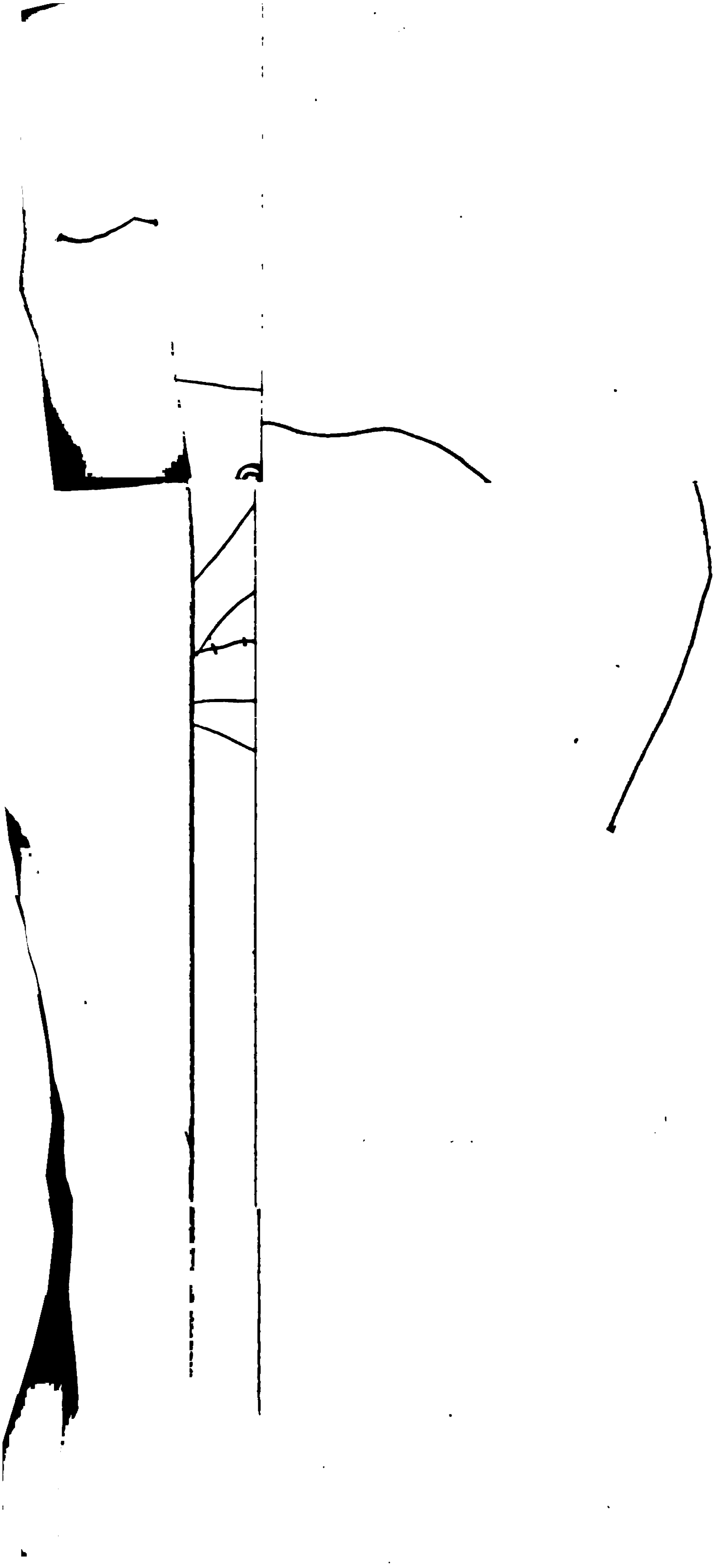
The Orange Boers, in a similar manner, occupied the Botha, Müller, Bezuidenhouts, and Tintwa Passes before the evening of the 12th.

The danger of subdividing into many small columns we have already discussed. On the British side the Dundee–Glencoe–Ladysmith position was not well selected, and the coal fields at Dundee are hardly a sufficient reason for a determined resistance at the Dundee-Glencoe line, and the excuse of political and moral reasons is too often advanced to cover military mistakes. A concentrated position north of Ladysmith, with a right flank column at Glencoe, appears to be the most reasonable solution, but such a Glencoe force should have considered itself part of the Ladysmith main body and should not, therefore, have allowed itself to be surrounded, but should have retired slowly before superior forces towards Ladysmith or Colenso.

Gen. White had but 3,000 men available, as it was, with which to attempt to prevent the union of the separate Boer columns, each of which was his superior in numbers, and the large, and practically *independent* force at Glencoe tied him to Ladysmith. With the above arrangement he would have had at least 10,000 men available for the attack on the separate Boer columns, and nothing to look out for but his own communications. If, however, his attempts to prevent union failed, then his only course should have been to retire beyond the Tugela and occupy a strong position covering Pietermaritzburg and Durban.

The neglect of General Symons to occupy Dundee Hill, which commanded the British camp, cost him a hard fight. The battles of Glencoe, Dundee and Elandslaagte were really fought to redeem a bad position, made so by imperfect tactical dispositions. An energetic, combined struggle with one of the Boer columns from a good position north of Ladysmith would have been far better. As it was, the British frittered away their forces in advance guard and outpost affairs which had no effect on the advance of the Boer main columns.

General White's success at Elandslaagte was decisive, but it only reestablished a communication which had been unnecessarily lost, and it gave the Boer columns more time to complete their strategic plans and concentric march. Considered by itself, however, it was a well-planned and splendidly executed action. General Yule's night march from Glencoe, in presence of an enemy greatly superior in strength, was a remarkable achievement, and taken in connection with General White's cov-



.chievement, and taken in connection with General White's covering flank attack at Reitfontein constitutes an excellent tactical study.

The bravery of the British officers commands the respect and admiration of the world. In these days of strong defensive lines and the great power of weapons in warefare, it is more difficult than ever to induce the soldier to come up to the enemy's lines, to come in contact with the enemy—by which alone the tide of battle can be turned—, consequently the example set by the officer comes more than ever into play, is more than ever a necessity, and certainly the British officers left nothing to be desired in this respect. The British loss in officers at Glencoe was 14½ per cent. of the total losses: at Spicheren the Germans lost in officers 4½ per cent. of the total losses. Whether or not the officers exposed themselves unnecessarily is a very difficult question to decide: it is the officer's duty to get his men forward, to keep them under control, and to economize their offensive power until the crisis is over, and if he stops to consider his own safety he is liable to miss his main duty; on the other hand, a high percentage of officers killed or wounded is very demoralizing. Between these limits he must choose, and the best course of action left open to the officer appears to be to get his men forward as well as he can without too much exposing himself, but if it is necessary to advance farther, and there is danger of lagging if this method is kept up, then he must expose himself.

The campaign in South Africa, the first to fully illustrate the effect of the modern magazine rifle and of smokeless powder, furnishes no new principles of strategy or tactics, but substantiates the conclusions long ago reached by the best authorities from a careful consideration of all the elements of modern warfare.

The reason that the results have impressed the world as unexpectedly great is that acts speak so much louder than treatises, even to professional men, and that the principles, heretofore known only to the initiated, now suddenly become the world's property.

The first great principle, long since established, which it emphasizes is the power of the *offensive*, strategically and tactically, and the fact that this offensive alone, in spite of all the new power of the defence, can furnish *decisive* results. In this early stage of the campaign the offensive is largely with the Boers, yet even here the limitations of their offensive power,—in failing to strike hard when they had the opportunity, and more especially in neglecting that other essential element of the offensive, *pursuit*,—is but too apparent.

Another important principle of the art of war is the correct estimation of the enemy's preparedness and strength. The one great cause of the early British disasters was their entire underrating of their enemy's offensive and defensive power. But many another nation has made this mistake, for example, France in 1870 and Russia in 1877, hence, this is not so surprising, especially when we consider the great distance of the scene of action from the home country. Of course, this error of judgment falls upon the supreme heads of the army command and upon the diplomatic department, and does not concern the troops in the field.

Any other nation, under similar circumstances, might have made the same mistake, and yet history teaches us that wars against irregular troops, defending their country and their homes, are always to be rated among the most difficult undertakings. And when in addition the nation attacking has to do so over a long line of communications, extending across the ocean for thousands of miles, and against a nation well led, and fully armed and prepared, the difficulties increase a thousand-fold.

Another great prinple of strategy that finds application in this campaign is the danger of holding on to what appear to be important points in the theatre of operations with large portions of the army of operations. The lesson of Metz, which caused France the loss not only of Bazaine's army but also of Mac Mahon's at Sedan, was not taken to heart by the British authorities. White's decision to hold Ladysmith, and the announced intention to retain possession of Mafeking andKimberley, tied the hands of the British leaders in the field, and increased the difficulties of the situation. The lesson to be drawn is that armies should never allow themselves to be shut up in fortifications, except when there is no other means left them to save themselves from destruction.

Still, simple as the principle is, it is so different in practice from what it appears to be in theory, that criticism must be passed with caution. If, as is stated, the fall of Ladysmith and Kimberley would have been the signal for a general uprising of the Dutch Boers in Cape Colony, the entire question at once assumes a different aspect, and cannot be answered on purely military grounds.

The principal tactical principle that has been corroborated by the battles in South Africa is that the purely frontal attack is no longer successful. It must be combined with flank attacks, but, since the latter will generally be met by counter-measures on the part of the enemy, converting them again into frontal attacks, these counter-attacks must be continued and extended into far outflanking movements, requiring much time for their execution, during which, between the two original fronts, a contest for position is taking place. These tedious maneuvers are rarely practiced in the time of peace, because they take up so much time, but they should be to make them second nature to the soldier. Moreover, many portions of the line, even of an army acting offensively, must stand temporarily on the defensive. Such portions should resort immediately to intrenchments, hence the necessity for practice in this important branch. In consequence of the growing importance of intrenching on the field, high authorities claim that the subject of temporary fortification and field intrenchment should be embodied directly in the drill regulations.

In the way of organization the only striking feature in this campaign is the great use made of mounted infantry, which constitutes on the side of the Boers, indeed, the principal force, but is also much used by the British. The advantage of such a force is undoubted, especially for reconnoitering and holding points important for the deployment of the main body. This suggests that the cavalry be trained to regard its fire-arm not as its exceptional but as its principal weapon, and that it be trained to fight on foot even more thoroughly than has been the custom in the past.

APPENDIX.

The strength and composition of the British Forces in South Africa at the outbreak of the war was as follows:

THE NATAL FORCE.

The Natal Force was part of the Cape Colony force up to the middle of October, and Major General Symons was in command of it. Afterwards General White, who had been in command of the Cape Colony forces, was sent to take command of the Natal force.

Infantry.

1st battalion Liverpool Regiment (originally in Cape Colony, sent to Ladysmith September 25)	750
1st battalion Leicestershire Regiment (originally in Ladysmith, sent to Glencoe September 25)	800
2d battalion Royal Dublin Fusiliers (originally in Ladysmith, sent to Glencoe September 25)	750
1st battalion King's Royal Rifles (at Glencoe)	750
2d battalion King's Royal Rifles (at Ladysmith, embarked at Calcutta and Bombay September 29)	750
1st battalion Devonshire Regiment (at Ladysmith, embarked at Calcutta and Bombay September 29)	800
1st battalion Manchester Regiment (at Ladysmith, arrived at Durban September 15)	750
2d battalion Gordon Highlanders (at Ladysmith, embarked at Calcutta and Bombay September 29)	800
1st battalion Gloucestershire Regiment (at Ladysmith, embarked at Calcutta and Bombay September 29)	800
1st battalion Royal Irish Fusiliers (at Glencoe, sent from Cairo)	700
	7,650

Cavalry.

5th Lancers (originally in Pietermaritzburg, sent to Ladysmith September 25)	400
5th Dragoon Guards (at Ladysmith)	400
18th Hussars (originally in Ladysmith, sent to Glencoe September 25)	450
19th Hussars	400
	1,650

Artillery.

Field batteries No. 13, 21, 42, 53, 67 and 69 and the 10th mountain battery (42 guns in all)	1,218
Field batteries No. 18, 62 and 75 (18 guns in all) expected shortly from Aldershot	530
	1,748

3 of the batteries were originally in Ladysmith, sent to Glencoe September 25; 3 batteries (21, 42, 53) came from India.

Engineers (Pioneers).

Field companies No. 7, 8 and 23 and the 29th Garrison Company	600

Train.

Companies 9, 15, 31 and 41	300

Volunteers.

Natal Volunteers	760
Natal Carabiniers	120
Imperial Light Horse	500
Durban Volunteers	750
Mounted police of Natal (with 9 guns)	550
	2,680
	14,628

Total 69 guns and 14,628 men.

THE CAPE FORCE.

Infantry.

1st battalion Northumberland Fusiliers (sent from Aldershot)	770
1st battalion Royal Munster Fusilers (arrived at Cape Town September 15)	750
1st battalion North Lancashire Regiment	800
2d battalion Berkshire Regiment	750
½ 2d battalion Yorkshire Light Infantry	320
1st battalion Border Regiment (sent from Malta)	700
	4,090

To arrive October 29th :

2d battalion Rifle Brigade (sent from Crete)	700
2 companies Garrison artillery No. 14 and 23	200
5th and 22d Companies Train	150
	5,140

On the Western Border.

Estimated (mostly volunteers)	4,000
Naval Brigade, landed from the fleet at Cape Town (4 guns)	1,000
Total	10,140

Field Batteries, No. 18, 62 and 75. 9th Lancers.

Grand Total, 24,768 men and 69 guns.

The Mobilized Army Corps.

General Sir Redvers Buller.

FIRST DIVISION.

Lieutenant-General Lord P. Methuen.

1st Brigade (Guards). Major-General Colville.	2d Brigade (English Brigade). Major-General Hildyard.
3d battalion Grenadier Guards (from Gibralter).	2d battalion Royal West Surrey Regiment.
1st battalion Coldstream Guards (from Gibralter).	2d battalion Devonshire Regiment.
2d battalion Coldstream Guards.	2d battailon West Yorkshire Reg't.
1st battalion Scots Guards.	2d battalion East Surrey Regiment.
Supply column (Train Co. No. 19).	Supply column (Train Co. No. 26).
Litter Bearer Co. No. 18.	Litter Bearer Co. No. 2.
Field ambulance No. 18.	Depot Field ambulance.

1 Squadron 14th Hussars.
Field batteries No. 7, 14 and 66 (6 guns each).
Ammunition column (1 reserve gun).
Field engineer Co. No. 17.
Supply column (Train Co. No. 20.)
Field ambulance No. 19.

SECOND DIVISION.

Major General Sir C. F. Clery.

3d Brigade (Scotch Brigade). Major-General Wauchope.	4th Brigade (Light Infantry.) Major-General Lyttleton.
2d battalion Royal Highlanders (Black Watch.)	2d battalion Scottish Rifles (Cameronians.)
1st battalion Highland Light Infantry.	3d battalion King's Royal Rifle Corps.
2d battalion Seaforth Highlanders	1st battalion Durham Light Infantry.
1st battalion Argyll and Southerland Highlanders.	1st battalion 1st Rifle Brigade.
Supply Column (Train Co. No. 14)	Supply Column (Train Co. No. 16).
Litter Bearer Co. No. 1.	Litter Bearer Co. No. 14.
Field Ambulance No. 8.	Field Ambulance No. 14.

1 Squadron 14th Hussars.
Field batteries No. 63, 64 and 73 (6 guns each).
Ammunition column (1 reserve gun).
Field engineer Co. No. 11.
Supply column (Train Co. No. 24).
Field Ambulance No. 3.

THIRD DIVISION.

Major General Sir W. F. Gatacre.

5th Brigade (Irish Brigade). Major General Hart.	6th Brigade (Fusilier Brigade.) Major General Barton.
1st battalion Royal Inniskilling Fusiliers.	2d battalion Royal Fusiliers.
2d battalion Royal Irish Rifles.	2d battalion Royal Scots Fusiliers.
1st battalion Connaught Rangers.	1st battalion Royal Welsh Fusiliers.
1st battalion Royal Dublin Fusiliers.	2d battalion Royal Irish Fusiliers.
Supply Column (Train Co. No. 30).	Supply Column (Train Co. No. 36).
Litter Bearer Co. No. 16.	Litter Bearer Co. No. 17.
Field Ambulance No. 10.	Field Ambulance No. 11.

1 Squadron 14th Hussars.
Field batteries No. 74, 77 and 79 (6 guns each).
Ammunition column (1 reserve gun).
Field engineer Co. No. 12.
Supply column (Train Co. No. 33).
Field Ambulance No. 7.

CAVALRY DIVISION.

Lieutenant-General J. D. P. French.

1st Brigade.

Major General Babington.

6th Dragoon Guards.
10th Hussars.
12th Lancers.
Horse Battery R (6 guns).
Ammunition Column (1 reserve gun).
Field engineer troop.
1st battalion Mounted Infantry.
Supply Column (Train Co. No. 13).
Litter Bearer Co. No. 9.
Field Ambulance No. 9.

2d Brigade.

Major General Brabazon.

1st Dragoons.
2d Dragoons.
6th Dragoons.
Horse Battery O (6 guns).
Ammunition Column (1 reserve gun).
2d battalion Mounted Infantry.
Supply Column (Train Co. No. 11).
Litter Bearer Co. No. 12.
Field Ambulance No. 6.

CORPS HEADQUARTES AND RESERVE.

1st battalion Royal Scots.
Staff of the 14th Hussars.
13th Hussars.
Field Artillery Regimental Staff.
Field Artillery Battalion Staff.
Horse Artillery Battalion Staff.
Horse Batteries G and P.
Field Batteries No. 4, 38 and 78 (6 guns each).
Howitzer Battalion Staff.
Howitzer Batteries No. 37, 61 and 65 (6 guns each).
Engineer Regimental Staff.

Pontoneers section.
1st Section Telegraphists.
Field Engineer Co. No. 26.
1st Engineer field park.
1st and 2d Balloon Section.
10th Railroad Co.
Ammunition Park.
Supply Column (Train Co. No. 21).
Field Bakery No. 40 (Train).
Field Ambulance No. 5.
Supply Park (Train Cos. No. 4, 29 and 42.)

TROOPS FOR LINES OF COMMUNICATION.

Lieutenant-General Sir Forestier-Walker.

2d battalion Northumberland Fusiliers.
2d battalion Somersetshire Light Infantry.
2d battalion Duke of Cornwall's Light Infantry.
1st battalion Welsh Regiment.
2d battalion Northamptonshire Reg't.
2d battalion Shropshire Light Inf'y.
1st battalion Gordon Highlanders.
1 Balloon Field Equipage.
4 Train Cos. (6, 8, 28 and 35.)
4 Stationary Field Hospitals.

4 General Field Hospitals.
2 Principal Depots for Medical Supplies.
3 Advance Depots for Medical Supplies.
4 Hospital Sections.
2 Hospital Ships.
4 Companies Army Ordnance Corps (1, 2, 3 and 4.)
1 Corps Pay Station.
1 Infantry Depot.
1 General Depot.
2 Remount Depots.

Captain JOHN P. WISSER, 7th Artillery.

[To be continued.]

ROLLER BEARINGS FOR ARTILLERY.

The Boer war has demonstrated very clearly the necessity of bringing into action on the field of battle guns of the heaviest caliber possible, and we may expect to see in future wars every effort made to use the most powerful types of ordnance. The only limit in this direction will be the question of transportation. As, aside from railway transport, this depends largely upon the draft or force of traction required, anything which lessens the draft will enable the present guns to be handled with greater ease and mobility, or lead to the adoption of the heavier calibers from which a greater effect can be obtained.

The essential feature of mobility can be obtained either by improvements in gun and carriage which will reduce the weight per horse or by devices which lighten the draft. That the draft is too heavy in our present field and siege pieces most officers of experience are agreed. Our 3.6 inch gun has a weight per horse of 865 pounds which is far too great to give the requisite mobility. Thus the advantages resulting from increased caliber are sacrificed by lack of the necessary mobility. It is not too much to say that the question of draft for siege artillery is to-day the principal problem to be solved by that branch.

When the gun and carriage have been reduced to the lowest possible limit of weight which the best materials and design admit of, the draft can be lessened only by improvements in the axles and bearings and consequent reduction of friction.

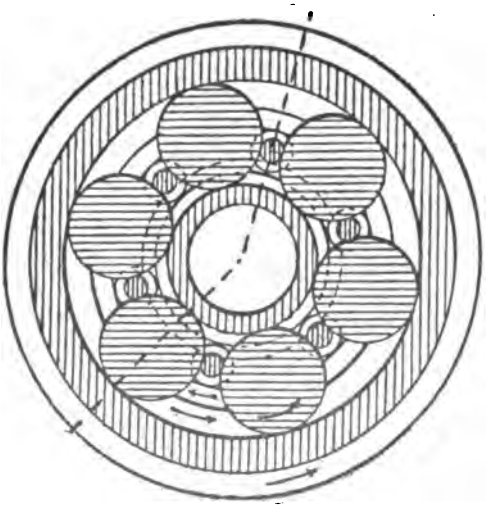
The ordinary parallel bearing gives good results only, as in machine shop practice, where ample and constant lubrication is assured. In other situations and especially on axle bearings gumming results with greatly increased friction.

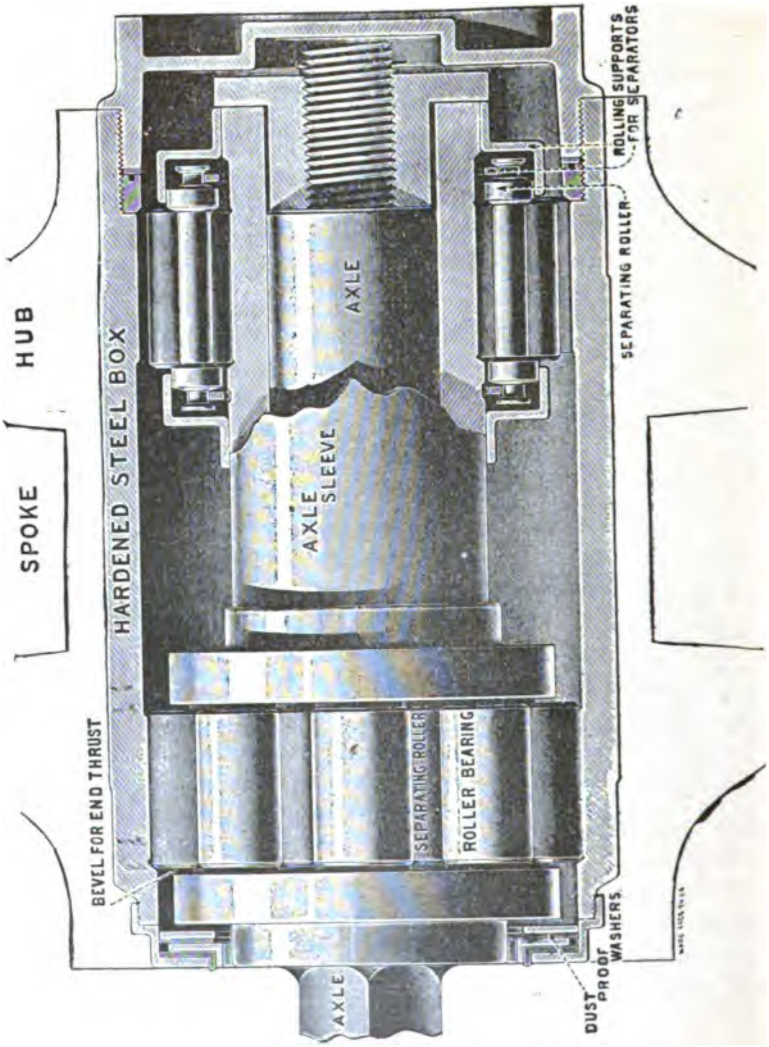
The application of ball-bearings in bicycles and other machinery showed what could be accomplished in the way of eliminating friction, and the principle has found wide application in other types of light machinery. When applied to heavier vehicles, however, it was found that crystallization of the balls and races ensued and a limit was soon reached in the practical application of this device. For heavy work a greater bearing surface is absolutely essential. Besides, the movement of the balls is not theoretically correct as adjacent balls rub on one another, the action being a combination of rubbing, rolling and spinning.

Many attempts have been made to obviate this trouble, such as caging the balls, providing curved races or by staggering them so as to prevent wear in one spot or line. None of these devices have proved successful for heavy work.

From ball to roller bearings the step was a natural one. While there are now numerous types of roller-bearings before the public, similar practical difficulties are experienced. While some types do good service under light loads they were found entirely unsuited to heavy traffic. For heavy work, as in artillery, a satisfactory roller-bearing must have a purely rolling action in all its parts, require little or no lubrication, and preserve its alignment under all conditions of service. It must be simple and practically safe from accident, dust and water. Unusual provisions must also be made to take up the heavy end thrust resulting from the great weights carried and conditions of service on bad roads.

It is believed that these severe requirements are met by a bearing of the general type shown in the figure, and that by the use of such a bearing artillery draft, it is estimated, can on level roads be reduced from 7 to 30 per cent. depending on the condition of the axles and the lubrication. Tests with roller bearings as compared to ordinary axles show that on level roads by use of the former the starting load is reduced fully 50 % and the pulling load or traction reduced in some cases to one quarter of its old value. In this type the wear is inappreciable, no adjustment is necessary and the wheel can be removed in the





ordinary way without disturbing the bearing. The action is purely rolling, the bearing surfaces amply large while the risk of breakage of a roller is reduced to a minimum. Lubrication every three or four times a year is all that is required, and in case of necessity the bearing will go for an indefinite period without lubrication and with no appreciable increase of friction. Even in case a roller breaks the only effect is to produce the ordinary parallel bearing. There is no cage to become distorted or be drilled out by the rollers.

The adoption of a correct roller-bearing for artillery is scarcely secondary to increase of caliber,—in fact the two are inseparably connected.

E. W. HUBBARD, Lieutenant, Seventh Artillery.

THE STUDY OF SEA-POWER.

Translated and reprinted by authority from *Marine Rundschau*.[*]

INTRODUCTION.

Although, with all the changes and improvements in war ships, war at sea has not altered its character, yet the conception of its influence and its historical significance (from the viewpoint of war) has become different from what it was in former times.

Military-maritime literature investigated the nature and changes of the great developments, which, in course of time, have become more and more decisive, and though it at first restricted itself to purely military subjects because of their predominating importance, it was eventually forced to invade historical territory in order to trace there the universal laws of military-maritime phenomena.

The works of Mahan mark, at the present time, the highest point of sea history literature, after these comes the modest work of Calwell.

Neither of these important historians restricted himself, as did their predecessors, to an analysis of the naval events during a certain period by connecting them more or less perfectly with general conditions. They considered it much more important to determine the influence exercised by the naval events upon history and upon the movements of armies, and analyzed the grounds and causes of these influences, thus giving to their works a highly philosophical character.

These works are therefore based on philosophical ideas which were essentially modern and can thus be regarded as a crude and primitive foundation for the study of sea-power which was formerly neither conceived nor investigated.

The possibility of creating this highly important study always appeared clearer the farther we proceeded in the open examination of the works of Mahan and Calwell, so that we considered it seasonable to conclude our criticism, already published, with the outlines of a scheme of study, which might in time be extended to a treatise on sea-power.

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[*] The article in *Marine Rundschau* is the authorized translation of the original in *Revista Marittima*. The latter also authorized our translation. ED.

The obstacles which beset the first scientific scheme, though only in outlines, of a study of sea-power, were not easy to overcome. None of the hitherto published works on land or naval battles serves as a support or guide, for the reason that they all have an exclusively technical military character, while the study of sea-power must have an exclusively philosophical historical character.

Mahan and Calwell furnished valuable material for the upbuilding of the study. This material, however, was not only insufficient and incomplete, but also in the form of opinions and principles promiscuously thrown together as the writers had occasion to express them, thus making it extremely difficult to give them a rational coordination.

We are only permitted to arrive at this coordination through an indication which, from the principles and opinions expressed by the writers in certain lines, corresponds to a guiding standard, thus assuring the harmony of the individual lines with a well defined, unified and properly constructed system.

The guiding standard selected by us was, to conceive sea-power as a world force with statical and dynamical qualities, and seek out, within historical bounds, the experimental data from which the laws were deduced and the special scientific study established.

The first attempt showed at once that the essential parts traced out in the historical works of Mahan and Calwell did not remotely suffice for the formation of the whole series of principles which were necessary for the upbuilding, however crude, of a new study.

The gaps to be filled up were extremely large and we despaired, in face of the proposed work, on account of our inability. The thought that the well inclined would forgive much, indicated the desirability of filling in these gaps from an article previously published by us, rather than maim the study by leaving such gaps unfilled.

It was thus that the thought of a study of sea-power originated: its foundation is formed by historical research and its structure is scientific.

The arrangement of the scientific study resulted from the conception of sea-power as a world force with statical and dynamical qualities and thus followed the division into two parts:

1. The statics of sea power.
2. The dynamics of sea-power.

The statics investigate the proportionate strength of the single elements composing the total power (Sea-power) whilst the dynamics treat of the manifestation of the single or joint powers under their dynamical conditions.

The first part considers the interdependent variable quantities under statical conditions and, for greater clearness, separates the investigation into three heads, thus:

1. Transcendental quantities,
2. Commensurable quantities,
3. Incommensurable quantities.

The first head comprises (a) genius, (b) invention, and (c) luck; the second (a) climate, (b) geographical position, (c) physical condition of the country, (d) location of the capital city, (e) density of population, (f) ramifications of sea trade, and (g) wealth; and the third (a) character of the people, (b) form of government, and (c) the civilization.

The second part of the study treats of sea-power under its dynamical activity, and, in order to satisfy the claims of order and clearness, distinguishes between (A) internal or national dynamics, and (B) external or international dynamics.

The study of internal dynamics investigates the movement of expansion from its origin to the instant it enters upon the international stage and examines particularly (a) the economical, (b) the political, and (c) the military forces; the study of external dynamics, on the contrary, is concerned with the automatic movement from its entrance on the international stage to the accomplishment of the expansion, and investigates the methods and historical precedents relating to (a) the occupation of the enemies territory, (b) the paralyzing of the enemies active forces, (c) the annihilation of the latter in battle and (d) the destruction of commerce.

This sketch of a study of sea-power should not only have permitted an extension of each individual theorem, but should have perhaps required it, in order that a complete treatment should correspond to the importance of the subject; but as such a presentation would have required the work of several years, the writer considered it more advantageous to restrict himself for the present, to a review which would present an epitome of a tangible and premeditated work, which, at the present writing, has not as yet been carried farther.

No one can be more convinced than we of the imperfections of the contents of this review, which might imply that we claimed to publish it authoritatively. We have not, however, proposed the problem of creating a complete system of instruction, but rather have met an urgent need, by employing and supplementing the rules derivable from the best works on war history, in order to sketch a tolerably crude system which shall contain a large part of the principles now scattered in numerous volumes. We hope, therefore, that these summarized principles, which have cost us infinite pains, will not be regarded by the reader as an aimless work.

Venice, January, 1899. D. BONAMICO.

PART I.

THE STATICS OF SEA-POWER.

The first part of the scientific study of sea-power concerns itself, as we observed in the introduction, with the transcendental, the commensurable and the incommensurable quantities. These three mutually dependent variable quantities and the rate of their infinitely small variations constitute the total forces (sea-power) in action under statical conditions. They furnish, therefore, the potential characteristics which permit the natural effects of the total forces to be foreseen, determined and directed.

I. THE TRANSCENDENTAL QUANTITIES.

Although the transcendental quantities present the least practicable and determinable characteristics of the statics of sea-power, they should not, for that reason, be separated from those forces which produce automatic effects, nor excluded from a consideration which is influenced in the highest degree by all existing causes. We have therefore considered it necessary to indicate briefly these transcendental quantities, the more so as neither Mahan nor Calwell cites genius, invention or luck as fundamental quantities of sea-power.

a. GENIUS.

With the assistance of the considerations already developed in the introduction to "Naval Strategy" (Strategia navale) we can lay down the following summarized principles for that part of the consideration which concerns genius :

1. Genius is the manifestation of a wonder which is compounded of intellect and feeling under the greatest tension.

2. The creative genius is moral in character if the warmth of the feelings predominate, and intellectual in character if the clearness of the mind is in the ascendant.

3. Favorable opportunities in co-operation with the conjuncture in which the wonder is performed are almost always the preliminary conditions for the manifestations of genius.

4. The appearance of genius can be foreseen and preordained whenever the conjuncture of the intellectual and moral efforts are favorable, but may be excluded by stormy outbreaks and social upheavals.

5. Genius, as history shows, is an appearance which is unified and condensed during an age of preparation and deliberation.

6. The state of genius is the privilege more of the young man than of the old.

7. The determination of the scale of genius depends on which of the elements, feelings, intellect or circumstances, co-operating in the production of the appearance, predominates.

8. The creative genius of an especially benevolent character owes its origin essentially to the sincerity of the feelings.

9. The special scientific nature of the intellectual faculties.

10. The prevailing military genius is an appearance which owes its existence to feelings and conjunctures in exact reciprocal relation to the prevalence of the intellectual faculty

11. A genius specially talented for naval battles is less dependent on feelings and circumstances than is one who is specially talented for military command.

12. Feelings and conjunctures influence armies much more than they do fleets.

13. The nations among whom imagination and feelings predominate are more likely to produce great military than great naval commanders.

14. On the contrary, the nations among whom intellectual development and knowledge predominate are more likely to produce great naval than great military commanders.

15. A proper preparation of the active forces and their internal organization is as indispensable for the manifestation of a naval genius as for a military one.

16. A genius for fighting whether demanded for land or naval battles manifests itself more through strategical than through tactical command: the *great* genius demands pre-eminent ability in both directions.

17. Genius is similar to invention through which it almost always manifests itself.

These characteristics of the most important of the transcendental quantities may be of great use in estimating the military status of belligerents, since their correct interpretation furnishes a guide for the determination of the probability of the isolated or more frequent appearance of genius during a national uprising.

If the principles enumerated are correct, the conclusion must follow that the nations who lack inquiring intellects, knowledge and internal military organization whilst predominating in feelings, inspiration and imagination, have no talents for creative genius in naval affairs and need hope for but little from their navy.

Applying these characteristics to the Chinese-Japanese War, we find with reference to the Japanese, an abundant warlike creative power for land as for naval battles in the individual as in the nation, for they have intellect in abundance, though not of the highest degree, penetrating minds, knowledge, military organization and feeling. Applying on the contrary, the same characteristics to the Spanish-American War, we find neither in the Spaniards nor the peoples of the United States, in the individuals nor the nations, conspicuous manifestations of warlike genius.

b. INVENTION.

The internal reciprocal relations which unite genius with the means of its manifestation—invention—indicate the expediency of tracing the fundamental characteristics which determine the influence of invention upon historical events, particularly in so far as they relate to the study of sea-power.

The considerations which are developed in a previous discussion may be summarized and completed by the following principles :

1. Invention and discovery are the products of genius and are its possible consequences, they must therefore be regarded, particularly in so far as they relate to naval efficiency, as mutually influencing quantities.

2. Invention generally appears as a material and determinate element of force or as an idea which resolves itself into a system.

3. The scale of values of inventions is hard to fix, but may, perhaps, be stated as follows :

    (a) Universal and persistent,
    (b) Universal and transitory,
    (c) Local and occasional.

4. To the first kind belong the great moral and scientific inventions.

5. To the second the great scientific applications.

6. To the third the progress in professional vocations, if we conceive armies, fleets and colonies as more or less artistical and scientific professions.

7. According to the character of the phenomena which they produce, inventions may be divided into those which destroy and those which develop; this division, however, does not define clearly or definitely, the particular value of the phenomena.

8. The three kinds of phenomena of invention contribute each their share to the potentiality of sea power. Since the first and second kinds are universal, they have but little influence on the proportionate value of sea-power, whether in space or time: the third kind, on the contrary, produces a definite variation in the proportionate strength of sea-power.

9. These inventions gain an importance which corresponds to the extension of their sphere of action and to the intrinsic force with which they exert themselves.

10. An invention which exercises its influence upon the whole civilization is more effective proportionally than that which exerts itself in but a single channel of civilization or in but a single branch of international or national activity.

11. If any one of the three kinds of inventions and particularly any one that has been appropriated, is made use of, it becomes a more or less valuable and effective element of the proportionate strength.

12. The monopoly or exclusive use of an invention, in whatever direction employed, gives abundant results as a consequence.

13. The war power and particularly the naval power is capable of undertaking the rapid and forcible operation of an invention.

14. The results of war are full of the consequences of a system or means employed by the victor which was unknown to the vanquished.

15. Inventions consisting of new ideas which appear as a new system of war science relating to organization, strategy or tactics, have generally a more decided, more extended and more permanent effect, than those which are material and palpable and consist of new or improved instruments of war.

16. Almost all the great commanders distinguished themselves through the employment of a new system of fighting and not through the employment of new or improved instruments of war.

17. The monopoly of a system can be kept secret longer than that of a new instrument of war; the details of the latter are quickly spread abroad if its value in war has been verified.

18. The monopoly of a system of fighting affects the entire army, whilst that of an instrument of war is restricted to a much narrower sphere. Therefore an invention which expands into a system, is proportionately more effective than one which embodies a material means of war. This, however, has not always been verified.

19. An invention which embodies a system of fighting, corresponds more nearly to the connected thoughts of scientific research : those nations in whom the activity of the mind is turned to the solution of intellectual questions have, therefore, a greater talent for intellectual than for material inventions.

20. On the other hand, the nations in whom the prevailing activity of the mind is turned towards the practical, the concrete and the professional, are better qualified to invent means of war than systems of fighting, since the invention of the former harmonizes with the tendency of their minds.

21. From a military standpoint an invention is considered so much the more effective as its working territory is more extended ; but not all inventions permeate with equal effect the various branches of armies or fleets.

22. The invention which is restricted to tactical grounds is generally less effective than one which is restricted to strategical grounds, and both again are less effective than one which embraces tactics, strategy and organization.

23. The inventions whose effects are restricted to tactical grounds include also those whose employment does not change the strategical character of the armies or fleets, and above all those which do not sensibly change the independence, mobility and management of the vessels.

24. The inventions which embrace tactical and strategical grounds, include those which do not sensibly change the nautical character of fleets, though they influence their tactical and strategical effectiveness.

25. To the inventions which permeate an army or fleet as a whole, must be added those which change the character of the latter by determining their existence on a new foundation.

26. Inventions of a purely tactical character are easier achieved and generalized than those which are also of a strategical character, and these again, easier than those which affect organization, though some inventions, like the compass, on account of their peculiarities, do not follow the principles just enunciated.

27. The temporary nature of inventions relating to scientific, professional and military subjects, admits the supposition that

they will proceed on essentially tactical grounds, but this does not exclude an additional ground of invention for submarine and aerial navigation.

28. The increasing inventive activity in the direction of war material favors the adoption of a new system, and therefore both, though more probably the former, would appear to be the unknown elements on which the proportionate strength of the active forces of the navy depend.

29. However great the internal strength and extent of inventions may be, they will still fail to prevent wars, and this in spite of the mellifluous assurances of the many, for the reason that war is a prevailing social phenomenon.

It follows from these considerations, that inventions are capable of producing great variations in the strength of sea-power, and must, therefore, be taken into consideration whenever it is desired to estimate correctly the military condition and proportionate strength of states.

C. LUCK.

The study of sea-power can no more exclude the luck of the quantities which contribute towards the determination of its strength than can any other combination of power.

All great commanders, Caesar and Napoleon particularly, with the possible exception of Frederic the Great, admitted the influence of predetermination, of fate, of chance, of providence, in short of luck upon human events. They also acknowledged the existence of an invulnerable quantity which resisted intellectual insight and keen analysis.

Admitting the above, no one has yet made the attempt to develop a doctrine of luck.

The majority admit, however, that the manifold events resulting from the successive action of material and intellect are largely, if not entirely, under the dominion of luck.

A few on the contrary, assert that luck exists but within the conceptions of human folly, and that therefore, the cleverest mathematician should be the luckiest man.

It is not our purpose to develop a physical or metaphysical theory of luck, but rather to determine whether luck has exercised a direct historical influence on historical events, particularly on events of naval value, and whether it will be able to exercise such influence in future.

All human history, particularly that pertaining to war on land or sea, confirms the fact that events have repeatedly, if not always, been swayed by influences beyond the scope of the learning of the century. Scientific learning was thus, at all times, always insufficient, and the enlightening researches undertaken always transcended the limits of human knowledge. So it has been and so also will it continue to be, respecting the insufficiency of human learning: the unknown, the unexpected, will also rule over events in the future and when the study of luck can be considered as a study of probability, then will those who make errors cease to deny them.

On every field of activity so many phenomena occur which elude not only calculation but also contemplation, that the number and influence of the unknown elements predominate over those whose approximate estimation is more certain and probable. We must conclude from this, that whatever be the conditions, a large space must be allowed for the presence of the unexpected and lucky elements.

Supposing we were able to give a proper demonstration of the action of luck in all phenomena, how shall we determine the characteristics which permit the prediction or possible estimation of the influence? Mahan and Calwell mention nothing relative to this estimation, though the former frequently alludes to favorable or unfavorable, expected or unexpected accidents; we will therefore, without attempting to wander dry shod over the entire shore of luck, pass lightly along its edges, in order to wade from the transcendental through to include the commensurable quantities.

The guiding principles of the influence of luck upon naval efficiency are, without the prejudice of erroneous views, as follows:—

1. Luck is the manifestation of the unknown whose essence, like that of ether, is imponderable and inexhaustable.

2. The elements which produce the phenomenon of luck may be separated into two kinds, the material and the intellectual.

3. The material elements keep themselves less aloof than the intellectual from the domain of anticipation which looks them sharply in the face.

4. The sphere of action of luck is so much the more extended as the phenomenon under consideration is more intricate.

5. Luck exercises a dominion over all channels of action which is proportional to the intrinsic strength and unexpectedness of the phenomena which interfere with the events.

6. The most insignificant and casual causes may often exercise the most far reaching and decisive influence, in such a case luck dominates both men and events.

7. Men may occasionally succeed in conquering luck through knowledge, experience and daring.

8. Knowledge without experience seldom produces the daring which favors luck.

9. Knowledge coupled with experience almost always produces the daring which dominates luck.

10. Constant practical exercise facilitates the conception of the idea of the unknown concealed in it more than do theoretical investigations.

11. Nations like individuals may, corresponding to the knowledge, experience and daring which they possess, be favored by luck.

12. The constant exercise of military science presents a greater guarantee of daring and luck than does theoretical study.

13. The more luck depends on mere stated quantities, the less does it permit men to dominate it.

14. Since naval efficiency is a phenomenon complicated by material, intellectual and moral influences, it presents more room than any other for the invasion of luck.

15. The subtlety of mind which is characteristic of seamanlike genius is, as history shows, often incapable of grasping luck.

16. In order to dominate luck, sagacity, experience and daring in their highest development, are more necessary in maritime channels than in other channels of activity.

17. Although always more dominated by knowledge and experience, luck will nevertheless not cease, in future, to exercise its influence upon human events.

However destitute this guide may be, it forms nevertheless, for want of a better, the first inner nucleous around which the study of luck may be concentrated, and this, whatever may be its appearance, presents an interest which can not be neglected.

On the strength of the conceptions perfected above, and experience confirms them, we assert that the Americans and Japanese have more probability of being favored by luck than their adversaries, and believe we are not in error when we further assert that the British Navy, viewed from its acknowledged superior strength, and considering the daring derived from knowledge and naval war experience, will have, now-a-days, the greatest probability of being favored by luck.

We commend these first researches on a presentation of the transcendental quantities of naval efficiency to the kind indulgence of the reader, reminding him that we had, as it were, to suck the three classes of theorems from our finger tips.

2. THE COMMENSURABLE QUANTITIES.

The part of the study of naval efficiency which embraces the commensurable quantities, namely, climate, geographical position, physical geography, location of the capital, density of population, ramifications of sea trade and prosperity, has been most investigated and furnishes the most valuable, though not always the most complete, material for the study of sea-power.

For this part of the study we are indebted to Mahan who, in the first section of his work, has analyzed the influence of some of the fundamental quantities of naval efficiency and expressed occasional opinions by way of summing up, which, when compiled, form a valuable contribution to the study of sea-power.

Before we yet knew the work of Mahan, we had already laid down some characteristics of sea-power in both the first chapters of our "Naval Strategy" (Strategia navale) and had sketched a foundation for a study which, though far from perfect, we were yet enabled to complete by the aid of the work mentioned.

Now that the task which we have here undertaken has reached its end, we consider opportune to place the summarized opinions scattered throughout Mahan's works under the form of principles, filling up the gaps with some suitable rules.

a. CLIMATE.

Mahan has not taken up climate under the elements of sea-power, but since he occasionally cites the influence ot climate upon the origin and development of sea-power under the head of physical conformation, it appears logical to conceive climate as a separate quantity whose influence upon naval efficiency is derived from the following principles:

1. Climate exercises its influence particularly during the period of conception and initial development of sea-power.

2. A too tempestuous and severe climate, exercising an excessive dominion over man and his means of existence is but little favorable to the conception and initial development of sea-power.

3. A too mild and peaceful climate, which promotes inactivity and apathy does not call forth the strength which is indispensable to the development of sea-power.

4. Since the mode of living depends particularly on climate, the latter must be such that it favors an external expansion within the given means much more than an internal one.

5. A long period of conception, if it does not prove abortive, provides the strength for a powerful development.

6. A climate which is too favorable to the origin and development of naval affairs does not generally favor the vital energies of those functions which are indispensable to the expansion of the military and maritime faculties.

7. If the climate is unfavorable it presents difficulties to the origin and initial development which are hard to overcome; should they however be overcome, there would result as a recompense a condensation of forces specially applicable to the navy.

8. Since naval efficiency is very vulnerable and easily subject to deterioration, this defect must be compensated by education and sustained effort on the part of the state, whenever the natural energies owing to too mild a climate are insufficient.

9. Since aspirations towards the sea are not born in man, they must be aroused through climatic agencies and stimulated to a higher tension through the vital powers of the state.

10. Considered from a military point of view, climate is a defensive and never an offensive quantity, where activity depends on how far it dominates man and his means of sea trade.

11. Climate never ceases to exercise its defensive influence and may often be the aggressive factor in determining maritime rank.

12. It is generally assumed that climate exercises a slighter influence on sea-power than it actually does.

13. Rowing and sailing fleets were wholly dependent on climatic conditions, and the fleets of to-day are more so than is generally admitted.

14. The knowledge of climatic and meteorological conditions including that of their corresponding trustworthiness was and is a condition of the efficiency of sea-power.

These few propositions epitomize the conditions which govern the origin and development of sea-power; they are applicable alike to the past as to the future since the fundamental quantities of naval efficiency do not change.

b. GEOGRAPHICAL POSITION.

This part of the study of naval efficiency is treated by Mahan with perhaps the greatest completeness and since Calwell also presents a few considerations on this subject we may, with so much the greater confidence present the following characteristics:

1. The geographical position exercises a predominating influence upon all epochs and upon all branches of sea-power.

2. The most efficient geographical position is one which guarantees in the highest degree, the inviolability of its own territory and permits the greatest employment of its naval dominion.

3. An island fulfills the first condition if its distance from other countries is such that it suffices, with the assistence of the means of defence, to insure the material existence against the threatening aggressors.

4. How far for this purpose the distance over sea must be is not determinable by itself, but must alone be determined in proportion to the stability of the naval dominion which is exercised and to the quality of the naval forces which resist this dominion or can be destroyed by it.

5. If the island can be surprised by crossing the intervening sea in a twenty-four hour voyage, the distance will form no effective defence; the latter, in such cases, can only be assured through the predominance of the other means of defence.

6. A great distance over sea from other countries is always an effective element of power since it does not diminish the opportunities for expansion and attack.

7. It is also always more favorable to the defence however detrimental it may be to their own expansion and attack.

8. The advantage which the island position presents for the defence becomes still greater, if every dissension between land and sea-power, inevitable in a country having also a land boundary, is avoided.

9. However great the distance from other countries may be, it can not assure the invulnerability of the territory without adequate assistance from the other means of defence.

10. The island position is an effective element of defence only so far as it permits the advantageous employment of the other means of defence and the definite unification of the system.

11. A peninsula assumes a greater or less share of the advantages of the island form, according as the character and extent of the land mass separating it from other countries is a greater or less hindrance to extension by land.

12. The peninsula and related forms excluding land boundaries, have exercised historically, great sea-power, and are not debarred from continuing to do so in the future, unless the peninsula position should develop dissention between the land and sea forces and prevent the unification of the system, as well with respect to expansion, as to defence.

13. If the position of the peninsula develops an internal and

external dissension between the land and sea forces, thus favoring land extension and opposing a well developed, unified economical and military system, then will a dominant and permanent sea-power be developed only under exceptionally favorable conditions of the otherwise effective elements of power.

14. The strength of attack derived from geographical position is a quantity which depends particularly on those elements which admit extension and dominion at sea.

15. Extension is particularly favored by a central position in the sea basin ; such position is highly useful to commerce which is thus least likely to be interrupted and therefore most likely to be profitable.

16. The central position is stronger in exact proportion as it is favorably located with reference to the total commercial intercourse of the sea basin.

17. The law of attraction acting towards the center from all movable elements scattered in the sea basin is always so effective that it produces a constant increase in the activity of the center—of the heart.

18. The activity of a particular sea basin by the commerce of the world differs, consequently there are different degrees in the importance of the center. The more extended correlation of particular sea basins permitted by modern fleets, induced the location of a central system rather than a central station of the particular sea basin.

19. Those centers of arms of the sea which are not suitable for the correlation of the commerce of the world and therefore lie on the circumference with reference to the centers of the new systems will, regardless of the predominance already attained by extension, see their actual importance wane in future, unless the predominance of the military dominion compensates for the resulting weakness arising from the new systems.

20. The naval dominion in a particular sea basin depends on the military superiority, and its efficiency on the geographical position.

21. The domination of the sea basin depends on the domination of the trade routes, therefore, the country which possesses the central or nodal points of these routes dominates the sea basin both commercially and militarily.

22. If the sea basin does not possess any nodal points of particular value beyond the center or upon the outer limits, the central position, at which the greatest activity of the basin meets,

is the predominant one; on the contrary, the possession of such nodal points will, more or less, reduce this superiority.

23. In such sea basins the importance of a station at the center depends upon the extent to which the commercial intercourse between the nodal points can be controlled from it.

24. The possibility of operating on the inner lines always constitutes an advantage to the central location even if its importance is diminished through the presence of nodal points beyond the center or upon the outer limits.

25. The central location presages permanent dominion if it itself determines the principal commercial points of the sea basin; it constitutes the greatest means of power which can be derived from a geographical position if it lies upon an island.

The extraordinary pre-eminence at all times of geographical position over all other quantities of sea-power and the ease with which it can be studied gives to the geographical position a prominent importance among the quantities on which naval efficiency depends.

C. PHYSICAL CONDITION OF THE COUNTRY.

The study which touches this function of sea-power is far more difficult to adduce under existing conditions than that which relates to geographical position.

For the complete and logical solution of the problem the following questions must be taken into consideration:

The natural features of the country; the configuration of the surface; the water distribution; the ratio of the land surface to the length of coast line and to the natural productive strength.

Mahan has treated these relations in a defective and imperfect manner, and as the contribution which we made to this subject in the investigations previously published by us, is unimportant, the solution of the problem is still far from complete. The following principles treated in the order given above are regarded merely as experiments which await completion by the future:

1. The natural features of the country may be simple or complex according as internal or external separating elements (mountain chains, seas) break the continuity.

2. An unbroken configuration of the country may always be regarded as one of the fundamental quantities of naval efficiency, just as much as political unity, if it does not exclude the existence of others.

3. Under this supposition the island form is the most valuable.

4. No island form, as history teaches, has fulfilled this condition, and it is quite doubtful if it ever will in future.

5. The peninsula has exercised a great effect in history whenever the natural features and political conditions were such that they permitted the employment of all or even of most of the power for the promotion of sea-power.

6. The configuration consisting of groups of islands or of large bays is capable, as history has shown, of creating a large and permanent navy provided it does not exclude a satisfactory employment of the other factors of power.

7. Island groups and bays are so much the more valuable natural features as their communications are more permanent and invulnerable, and the character of their natural divisions such as does not also imply political and military divisions.

8. Separating mountain chains, particularly those of great thickness, always hinder the unification of sea-power, even if they do not prevent the political unity of the state.

9. Separating mountain chains have a tendency to separate the forces which lean towards the sea, i.e., to split up fleets, and exercise a very pernicious influence in the same manner that separating seas exercise a negative one.

10. A water distribution which guarantees the greatest protection from without and the greatest capacity for expansion, best satisfies the demands of sea-power.

11. The protection from without afforded by a water zone is so much the more complete, the more invulnerable it makes the coast district without diminishing the safety of navigation.

12. If the character of the sea coast transcends the limits of a satisfactory coast defence, the capacity for expansion is diminished.

13. The defensive zone suffices if it excludes the possible and efficient bombardment by the ordinary warship and necessitates the use of pilots for the native commerce.

14. The necessary and sufficient preliminary conditions of coast defence are seldom found fulfilled; their importance is modified in proportion as they approach their limits.

15. Defensive boundaries have no value in themselves; this depends upon the character of the ships and consequently the lessons of the past can not be applied to the future.

16. If the water zone does not guarantee sufficient defence it is almost always injurious.

17. The external water zone is complete if it agrees with the requirements of defence and permits an effective and economical perfection of the fleet.

18. A perfected internal water system is always favorable to sea-power if it does not prevent or abridge political or military unity.

19. The more nearly the inland water system resembles that of the circulation of the blood in the human body, the more valuable it is, since it permits the removal of the sea trade center into the interior and the economical and effective perfection of the fleet.

20. The inland water distribution is more important to sea-power than that of the coast zone, and will exercise, in future, a more and more predominating influence.

21. The extent of the country, whatever its natural features, frequently exercises upon sea-power a disproportionate influence; more properly speaking, this influence depends upon the ratio of the land surface to the length of the coast line.

22. Under otherwise similar conditions, a greater extent of land presupposes a greater sea-power unless the character of the country favors the predominance of a land power.

23. Since the extent of country and the proportionate density of population increase in proportion to the square of the linear dimensions, a division of the country by separating elements may be advantageous in order to avoid an excessive increase of continental interests.

24. The length of the coast line when extended by the river system is sufficient, if the predominance of the sea over the continental interests is assured.

25. Large bays, large rivers and navigable canals constitute the foundations for the predominance of sea-power much more than do island groups.

26. The division of a country by large, easily accessible, seas or rivers may more likely prove a source of weakness than of strength unless they are defended by an adequate fighting force.

27. The sea-power of a country also depends on the ratio of the extent of the country to its natural productive power.

28. The natural productive power of a country has a twofold importance according as it produces the sustenance of the population or the raw material of maritime industry.

29. An insufficiency of the means of sustenance derivable from agriculture, cattle breeding or the fishing industry, arouses an impulse to extend outwardly but opposes the development of the faculties which strengthen and make it useful, whilst a superabundance of such sustenance either excludes a natural extension entirely or only permits it to enter transitorily into the phenomena, if artificially called into life.

30. A good equilibrium among the conditions essential to life is more favorable to the strengthening of naval efficiency than to its origination ; the latter, as a matter of fact, arises through the necessity for this means of existence.

31. With the exception of those which emanated from land forces, all the great naval states had a laborious origin owing to the poverty of the country and the severity of the climate.

32. The production of the raw material pertaining to the maritime industry is as indispensable a condition for the origin as for the development of sea-power.

33. An insufficient production of the raw material pertaining to maritime industry always weakens sea-power and obstructs its natural extension.

34. The quantity as well as the quality of the insufficient productive power may cause heavy shocks during a long period of war.

35. An excess of the raw material pertaining to maritime industry is always an incentive to extension and a firm foundation for sea-power.

36. The nations who lack the most essential raw material are forced to measures which make the vitality of sea-power artificial.

37. The physical conditions of the country exercise an influence which is so much the more lasting and permanent, as those pertaining to agriculture, land continuity and water distribution, length of coast line and productive strength of the country are better fulfilled.

d. THE LOCATION OF THE CAPITAL.

Mahan has not expressed any views concerning the influence which the location of the capital may exercise on sea-power.

The principles which the introduction of this new element justify have been analyzed by us in the second chapter of "Naval Strategy" (Strategia navale), so that it only remains for us to summarize and complete them here in the following :

1. The influence which the location of the capital exercises upon land and sea-power is almost always misjudged.

2. The location of the capital is almost always the natural consequence of the economical and military movement of the country.

3. The capital city of those states which, particularly at their origin, were continental, lies nearly in the center ; that of those

whose development towards the sea predominated, lies without the center or upon the extremity of the boundary of the country.

4. Since the capital city forms the heart of the country, its location must be such as will permit a satisfactory defence against unforeseen menaces, and present at the same time, a guarantee that it can exercise the greatest influence on the to and fro movement of the national forces.

5. If the movement tends in a particular direction from the beginning as, for example, in England towards the Channel and in the United States towards the Atlantic Ocean, etc., the capital city will be shifted in the direction of the movement of extension.

6. The existence of equal motive forces in two or more directions, as for instance in France and Spain, causes a location of the capital city corresponding to a condition of equilibrium of the commercial and military systems.

7. The country's interest and the multiplicity of the channels of its national activity, indicate the central location for the capital city.

8. This location is always less favorable to the origin and development of sea-power.

9. Political revolutions, creating a new predominant direction of development, are followed by a change in the location of the capital, as for example, the removal of the capital of the Russian Empire from Moscow to St. Petersberg.

10. The more naval activity predominates in the movement of nations, the less will the location of the capital at the center correspond to the réquirements of naval efficiency.

11. The phenomena which have the greatest influence in determing an interior location for the capital, are mostly artificial, quickly exhausted and unsuited to give stability to the impulse of the people towards the sea.

12. The perfection of the connections and relations between the outer boundary and the center of the country, moderates the inadequacy of the central location but does not prevent it, particularly during a severe and continuous naval war.

13. The most influential capital city will be that which, lying at the center of the economical and military systems, lies at the same time, at that of the maritime activity, and also upon a river, bay or inland sea which permits the greatest possible commercial intercourse.

14. The central location is always less influential, whilst that on the border is too easily vulnerable: a location outside the center coupled with good internal water communication is best qualified to develop sea-power in peace as in war.

(To be continued.)

Translated by First Lieutenant F. E. HARRIS, 3d Artillery.

THE LAW OF PRESSURE IN GUNS.

Reprinted from *La Corrispondenza.*

The formulæ of interior ballistics give the initial velocity of the projectile with sufficient exactness, also the maximum pressure in a gun, but not the law of distribution of pressure at each point of the bore. Experimental determinations are, in this latter respect, equally without result. It is, however, of interest, especially in the study of the resistance of the piece or accessory parts, to be able to evaluate this pressure, at least to a certain degree of approximation, by proceeding from results already obtained (velocity and maximum pressure).

With this object in mind, if we examine the curves representing the development of pressures (or the accelerations of the projectile) as functions of time, we notice that these curves rise very rapidly up to a maximum and then fall away, passing through a point of inflection in order to assume a direction asymptotical to the axis of time.

The general character of such curves may be represented by an expression, such as

$$(1) \qquad P = P_0 \frac{t}{\theta} e^{1 - \frac{t}{\theta}},$$

in which P represents the pressure at the point where the base of the projectile may be at the instant t, P_0, the maximum pressure, and θ the time when this maximum occurs, the origin of time being fixed at the moment when the projectile commences to move.

From this equation (1), the various elements of the trajectory in the bore are easily deduced in explicit form by means of the following relations :—

$$(2) \qquad \frac{m}{\omega} \frac{du'}{dt} = P = P_0 P(z)$$

$$(3) \qquad mu' = e\, \omega\, P_0\, \theta\, V(z)$$

$$(4) \qquad mu = e\, \omega\, P_0\, \theta^2\, U(z)$$

in which m represents the mass of the projectile, u' its velocity in metres, u the distance in metres passed over in the time t, ω the cross section of the bore in sq. cm., P_0 the maximum pressure per sq. cm., e, the base of the Naperian system, z the ratio $\frac{t}{\theta}$, and finally, $P(z)$, $V(z)$ and $U(z)$ three functions expressed respectively by :

$$P(z) = z e^{1-z};$$

$$V(z) = 1 - (1+z) e^{-z};$$

$$U(z) = z - 2 + (z+2) e^{-z}.$$

By the aid of these formulae, we are now able to deduce practically the law governing pressures.

Let U′ be the initial velocity, U the total distance passed over by the projectile to the muzzle of the piece, and a the ratio of the maximum pressure to the mean pressure which, acting through the same distance, would give to the projectile the velocity U′; then

$$(5) \qquad a = \frac{2 \omega P_0 U}{m U'^2}$$

This parameter a is often used as a characteristic of the quickness of the powder in each particular case. It is about 3 for black powders, and from about 2 to 1.6 for smokeless powders. Its analytical expression, in our notation, is

$$(6) \qquad a = \frac{2\, U(Z)}{e\, V^2(Z)},$$

Z representing the value $\frac{T}{\theta}$ of z at the moment T when the projectile leave the bore.

Finally, dividing equation (4) by equation (3), member by member, we obtain, for the same value Z of z,

$$(7) \qquad \theta = \frac{U}{U'} \frac{V(Z)}{U(Z)} = \frac{2}{e} \frac{U}{U'} \frac{1}{a V(Z)} = \frac{U}{U'} \theta(a)$$

by representing by $\theta(a)$ the factor $\frac{2}{e a V(Z)}$, Z being already givin terms of a by equation (6).

It is readily seen that the elements of the point of maximum pressure are obtained from the formulae:

$$(8) \qquad u_0 = U \Phi(a), \quad \Phi(a) = \frac{U(1)}{V(Z)};$$

$$(9) \qquad v'_0 = U' V(a), \quad V(a) = \frac{V(1)}{V(Z)}.$$

Having thus calculated these elements, the table below gives those of a number of points which are sufficient to trace the curves of the various elements either as functions of time or as functions of distance.

$z=\frac{t}{\theta}$	0	1	1.35	1.50	1.5935 (*)	2.00 (**)	3.00	Z (***)
u	0	u_0	$2.1\,u_0$	$2.7\,u_0$	$3.13\,u_0$	$5.22\,u_0$	$12.08\,u_0$	U
u'	0	u'_0	$1.45\,u'_0$	$1.685\,u'_0$	$1.81\,u'_0$	$2.25\,u'_0$	$3.07\,u'_0$	U′
P(z)	0	1	0.95	0.91	0.88	0.736	0.406	P(α)
$\frac{d\mathrm{P}(z)}{dt}$	$\frac{2.7183}{\theta}$	0	$-\frac{0.247}{\theta}$	$-\frac{0.303}{\theta}$	$-\frac{0.3275}{\theta}$	$-\frac{0.368}{\theta}$	$-\frac{0.271}{\theta}$	$\frac{1-\mathrm{Z}}{\mathrm{Z}}\,\frac{\mathrm{P}(\alpha)}{\theta}$
$\frac{d\mathrm{P}(z)}{du}$	$+\infty$	0	$-\frac{0.067}{u_0}$	$-\frac{0.0709}{u_0}$	$-\frac{0.0712}{u_0}$	$-\frac{0.064}{u_0}$	$-\frac{0.035}{u_0}$	$\frac{1-\mathrm{Z}}{\mathrm{Z}}\,\frac{\mathrm{P}(\alpha)}{\mathrm{U}\theta(\alpha)}$

It is generally correct to take for the coefficient a, the value given by equation (5). But it agrees more nearly with theory, as also with experiment, to replace the mass of the projectile m in that formula by $m+\frac{\mu}{2}$, μ being the mass of the charge of powder.

By way of example, I give below an application of the method to some experiments performed in Russia by Zaboudski with a 10.5 cm. (4.13 inch) gun, using projectiles of various weights and powders of different kinds.

Weight of charge.	Weight of projectile.	Initial velocity.	Pressure at the breech.	Value of a	Value of θ	Pressure at the muzzle. (calculated)	Pressure at the muzzle. (observed)	Pressure at the muzzle. (corrected) by Zaboudski.
$1^{kg}.895$	$16^{kg}.3$	547^{m}	1722^{kg}	1.855	$0^{s}.00244$	314	323	309
$1^{kg}.657$	$16^{kg}.3$	505^{m}	1390^{kg}	1.805	$0^{s}.00274$	318	343	274
$1^{kg}.417$	$16^{kg}.3$	456^{m}	1045^{kg}	1.715	$0^{s}.00326$	272	311	261
$1^{kg}.895$	$14^{kg}.3$	568^{m}	1536^{kg}	1.761	$0^{s}.00259$	372	313	315
$1^{kg}.895$	$12^{kg}.5$	597^{m}	1389^{kg}	1.715	$0^{s}.00249$	361	318	336
$2^{kg}.350$	$16^{kg}.3$	598^{m}	1794^{kg}	1.660	$0^{s}.00260$	505		504
$2^{kg}.650$	$16^{kg}.3$	598^{m}	1716^{kg}	1.540	$0^{s}.00289$	566		570
$2^{kg}.186$	$16^{kg}.6$	562^{m}	1731^{kg}	1.815	$0^{s}.00245$	365	331	364
$1^{kg}.704$	$16^{kg}.3$	562^{m}	1764^{kg}	1.840	$0^{s}.00239$	378	328	363

In these examples, the parameter a has been calculated by taking into consideration one-half the mass of the charge as mentioned above.

Thus simplified, the method seems to me to be of practical application. In order to facilitate this I append a complete table of the different functions of the parameter a which enter in the preceding formulae and tables. They are sufficient to treat all cases arising under normal conditions, for *a* will always remain included between 1.2 and 4.

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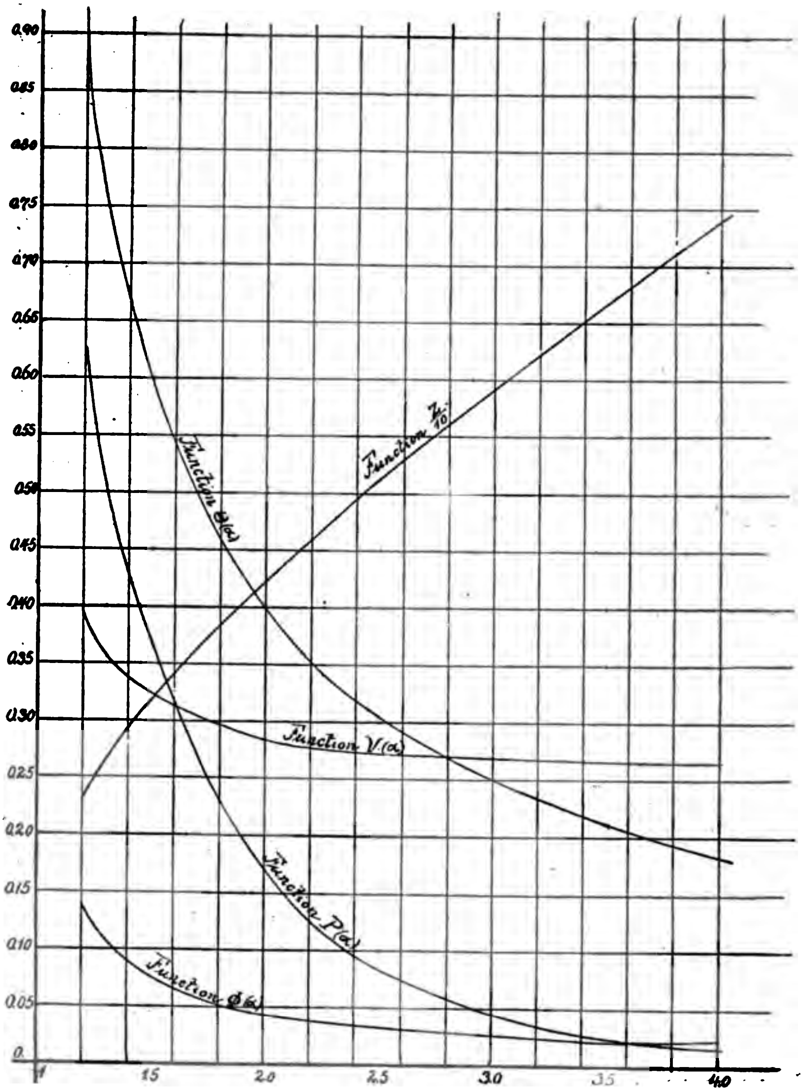
* Point of inflection of the curve of pressure as a function of distance.

** Point of inflection of the curve of pressure as a function of time.

*** Muzzle of the piece.

In order to convey some idea of the nature of these various functions their representative curves have been traced between these same limits of *a*.



a	Z	P(a)	θ(a)	Φ(a)	V(a)
1.2	2.30	0.627	0.915	0.141	0.394
1.3	2.63	0.515	0.766	0.108	0.357
1.4	2.92	0.427	0.667	0.087	0.333
1.5	3.18	0.360	0.593	0.074	0.319
1.6	3.40	0.308	0.540	0.065	0.311
1.7	3.62	0.264	0.497	0.058	0.303
1.8	3.83	0.227	0.460	0.053	0.296
1.9	4.03	0.195	0.427	0.048	0.290
2.0	4.23	0.168	0.398	0.044	0.285
2.1	4.42	0.145	0.374	0.041	0.281
2.2	4.60	0.126	0.353	0.039	0.278
2.3	4.78	0.109	0.335	0.037	0.276
2.4	4.95	0.095	0.319	0.035	0.275
2.5	5.11	0.084	0.306	0.033	0.274
2.6	5.27	0.074	0.293	0.031	0.273
2.7	5.43	0.065	0.281	0.030	0.272
2.8	5.59	0.057	0.270	0.029	0.271
2.9	5.75	0.050	0.259	0.027	0.270
3.0	5.90	0.044	0.250	0.026	0.269
3.1	6.06	0.038	0.241	0.026	0.268
3.2	6.21	0.034	0.233	0.025	0.267
3.3	6.36	0.030	0.226	0.024	0.266
3.4	6.51	0.027	0.219	0.023	0.266
3.5	6.66	0.024	0.212	0.022	0.266
3.6	6.80	0.021	0.206	0.022	0.265
3.7	6.94	0.018	0.200	0.021	0.265
3.8	7.09	0.016	0.194	0.020	0.265
3.9	7.25	0.014	0.189	0.020	0.265
4.0	7.40	0.012	0.184	0.019	0.265

E. VALLIER,
Major of Artillery.

La Corrispondenza Giornale di Scienze Militari,
November, 1899.

[Translated by Andrew Hero, Jr., 1st Lieut., 5th Artillery.]

PERFORATION FORMULAS.

I. GENERAL CONSIDERATIONS.

When a projectile of weight p and caliber a, impressed with velocity v or an energy

$$E = \frac{pv^2}{2g}$$

strikes a plate of thickness s, a part E_1 of its energy is expended in doing work on the plate, another E_2 in doing work on the projectile, and another E_3 remains in the latter or in its parts if the plate is perforated. We therefore have

$$E = E_1 + E_2 + E_3.$$

The energy, however, necessary to overcome the plate is given by

$$(1) \qquad E_f = E_1 + E_2,$$

and since we cannot generally calculate this energy by analytical methods we seek to do so by experimental means. With this object in view we attack the plate with continually increasing velocities until complete perforation is obtained, then measure the velocities v_1 and v_2 of the projectile on striking and leaving the plate respectively, and thus obtain

$$(2) \qquad E_f = \frac{p}{2g}(v^2_1 - v^2_2).$$

But, to determine the velocity necessary to overcome the plate, independently of the damage sustained by the projectile (damage which, with the same plate, varies with the form, system, material, construction, etc., of the same projectile) we must investigate and study E_1 and E_2 independently. Such study, however, especially with hard plates, is beset with serious and enormous difficulties, which we do not, in general, even attempt to surmount, because in practical firing interest centers rather in knowing what velocity a projectile must have to overcome a certain plate or, vice versa, what plate can be pierced by a certain projectile with a given velocity. It is evident, moreover, since projectiles are often upset while perforating, that for practical purposes it is more important than anything else to know E_f.

Every time, therefore, that new armor has been produced or adopted, experiments have been made for the purpose of determining data for the calculation of E_f in (2), and the experimenters have sought to represent the results by empirical formulas as functions of p, a, s, and v.*

It clearly appears, however, that these formulas cannot represent general cases, but that they are as much particular in their application as the power of the projectile employed in the experiments to resist deformation is less, and the capacity of the plate to facilitate deformation of the projectiles is greater. The formulas, therefore, that could be used with the most safety would be those relative to the wrought iron plate or to the homogeneous steel plate of Schneider, provided, however, they had been deduced from experiments made with good non-deformable projectiles. But often deformable projectiles were also used in the experiments against these plates, so that few of the formulas are applicable to the good conditions that now obtain ; among these, however, must be mentioned that of Weaver

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* Referring now to the single wrought iron plate, we recall that one of the first formulas was proposed at the end of 1861 by Fairbairn and adopted also by Noble. (See formula 4, sec. 2). It was based on the hypothesis that the mean resistance of the plate against perforation was proporiional to the area $\pi a s$ of the cylindrical hole sufficient to permit the passage of the projectile, and that consequently, the work of perforation was proportional to $\pi a s \times s$. Successive experiments, however, showed that the work of perforation did not increase proportionally to the square of s; the formula above was therefore modified by changing the exponent of the variable. Some authors have found that between certain limits the given exponent is constant and is comprised between 1 and 2; others that it must be expressed as a function of a and s, because the resistance of the plate besides varying with the caliber of the projectile diminishes with its own thickness, because the thicker the plate the greater the difficulties in its construction ; and others again hold that s and a should appear in perforation formulas under the relation $\frac{s}{a}$, because the phenomena observed during perforation varies with this relation.

Among the formulas most used we note those of De Marre (No. 19, sec. 2), of Muggiano (No. 9, sec. 2), and of Krupp (Nos. 13 and 14, sec. 2); it should also be observed that Krupp has obtained quite good results with a theoretical formula. More recently, however, Captain Tresidder has proposed another formula (No. 20, sec. 2) which is much used. He observes, on the basis of the experiments, that the energy necessary for perforation depends upon the circumference of the hole made and upon the time during which the plate applies its work of resistance, and that the thickness of wrought iron which a projectile can perforate is proportional to the work of the projectile per unit of its circumference per second. But if we consider a projectile impressed with the velocity strictly necessary for perforation and observe that at the instant at which the ogival head leaves the plate, the work of perforation is practically accomplished, the time will be approximately proportional to $\frac{s}{v}$, and therefore we may put

$$s = K \frac{pv^2}{a} \div \frac{s}{v} = K \frac{pv^3}{sa},$$

in which K is a constant.

It is notable that the Krupp formula (1880) and that of Tresidder (1895) are identical, if we except the numerical co-efficients, when similar projectiles are considered, and both differ but little from that of De Marre (1886).

for the soft steel plates of the Creusot type and the good projectiles of the Holtzer type.*

When the plate is hard and more especially when it is Harveyized the search for a good perforation formula becomes still more difficult, because of the greater differences between the various types of plates and because of the greater work E_2 consumed in upsetting the projectiles. For all these reasons great caution is necessary in the employment of perforation formulas and in the selection, in each case, of those which represent conditions most nearly similar to those under consideration. But that gives rise to inconvenience; it often happens that we have

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*The following are the criterions with which Weaver deduces his formula (*Journal of the U. S. Artillery*, 1892).

It has been observed in steel armor plate trials, that the surface of the plate about the point of impact shows signs of molecular disturbance throughout a superficial area of the plate, that appears to bear a definite relation to the caliber of the projectile. For armor plates of mean thickness, this area includes that portion of the surface within about two calibers from the edge of the shot hole. The molecular action is indicated by the increased temperature of this portion *immediately after impact* and by the bulge produced. It may be assumed from this, that the surface layer of the metal to this limit participated in the resistance, and it may be assumed, further, that the mass of the plate behind this surface layer was also involved; this is strongly confirmed by the appearance of the backs of the Annapolis and Indian Head plates, which, on an examination after the trials, revealed that the effect of the six-inch projectiles extended to a radical distance of about nine inches and the eight-inch projectiles to about eleven inches. All other trials of steel plates show the same front and rear bulges and heat circles.

From an examination of the results of a number of tests, and from subsequent application of the principle, there is reason to believe that when the diameter of the projectile is equal to the thickness of the plate, the metal involved in resistance will be limited to a disk about the point of impact, the diameter of which is 6.25 times the diameter of the projectile, the thickness of the disk being the thickness of the plate. Not only does the diameter of this resisting disk vary with the diameter of the projectile, but it also varies with the *diameter of the projectile and the thickness of the plate*. As a result of numerous trials and comparisons the law of this variation may be expressed by the following formula:

$$R = 3.125\,[1 + 0.014\,(s - a_1)]\,a_1$$

a_1 and s being expressed in cm."

"The weight P of the disk above mentioned will therefore be proportional to the quantity

$$[1 + 0.014\,(s - a_1)]^2\,a_1^2\,s$$

It is assumed that the metal of the resisting disk has an intrinsic power of resistance,—a property based on the resistance offered by the molecules of the metal to charge of position with respect to one another. This may be expressed in the ferm of the energy per ton necessary to produce a given change in the relative positions of the molecules, as, for example, that resulting from perforation of the plate by a projectile. The value of this factor will be a canstant for the same kind of metal, so that $pv^2 = P =$ a constant, v being the velocity necessary for perforation."

The examination of a large number of tests made with soft steel plates of the Creusot type and Holtzer projectiles led to the conclusion that the constant was equal to 2000 and thus formula 25 (sec. 2) was deduced.

Vallier finding it more convenient to use the formula for R:

$$R = 3.125a_1\,.\,10^{0.006\,(s - a_1)}$$

(which can be reduced to the preceding by developing the exponential into a series and omitting all terms after the second) has in like manner deduced formula 26 (sec. 2), and has observed that this formula, having been deduced from experiments made with well determined plates and projectiles, furnishes the means of comparing with these plates and projectiles other types of plates and projectiles. Denoting now, by E the energy of perforation as determined from the given formula for a plate of thickness s and projectile of caliber a and by

No. of formula	AUTHOR'S NAME.	KIND OF ARMOR.	FORMULAS.	USE OF FORMULAS AND REMARKS.
3	Gruson	Chilled cast iron	$\frac{p v^2}{\quad} = \left(\frac{s}{\quad}\right)^4$	Seacoast forts: $k = 0.12$ for cannoneers shields; $k = 0.09$ for the front plates with earth backing; $k = 0.08$ for the front plates with granite
26	Vallier	Schneider steel	$p v^2 = 2000\, a_1^2 s \,.\, 10^{0.012\,(s-a_1)}$	It is equivalent to Weaver's formula and is useful for Holtzer and Krupp projectiles; for the manganese projectiles of Hadfield multiply the second term by 1.1.
27	Foss	Nickel steel	$p v^2 = 10^{3.4521}\, s^{2.2}\, a_1^{0.7}$	For steel projectiles.
28	Vallier	Nickel steel	$p v^2 = 2500\, a_1^2 s \,.\, 10^{0.012\,(s-a_1)}$	For good steel projectiles.
29	Weaver	Harveyiz'd steel	$p v^2 = 2000(1.885 - 0.014 s)[1 + 0.014 (s - a_1) a^2 s$	For the first Harveyized plates and for projectiles of the Holtzer and Krupp types.
30	Vallier	Harveyiz'd steel	$p v^2 = 2000\,(1.885 - 0.014\, s)\, a_1^2 s \,.\, 10^{0.012\,(s-a)}$	
31	Vallier	Harveyiz'd steel	$p v^2 = 2000\,(2.356 - 0.0175\, s)\, a^2 s \,.\, 10^{0.012\,(s-a)}$	For the improved Harveyized plates (towards the end of 1897), and the best projectiles.
32	Krupp	Harveyiz'd steel	$p v^2 = 5800\, a_1 s^2$	For Krupp plates of medium thickness.
33	Davis	Harveyiz'd steel	$p v^2 = \overline{141.7}^2\, a_1 s^{1.5}$	For American plates and projectiles (recent type).
34	Vallier	Harveyiz'd steel	$p v^2 = 2300\, a_1^2 s \,.\, 10^{0.012\,(s-a_1)}$	For capped projectiles.
35	Davis	Harveyiz'd steel	$p v^2 = \overline{109.4}^2\, a_1 s^{1.6}$	For plates and capped projectiles of the American type.
36	Jacob de Marre	Steel	$p v^2 = 1.33 \,.\, 10^{3.1694}\, a_1^{1.5}\, s^{1.4}$	For small hard steel plates of Saint Chamond and small projectiles.

*The original gives this number as 15, but it must mean more than 30 and is most probably 45 as I have put it.—TRANSLATOR.

PLATES.

	NICKEL STEEL						chneider.	Compound.	Harveyized plates and capped projectiles.	
a / s	10	15	20	25	30	35	alibers.	Calibers.	Calibers.	a / s
4	6.0	5.8	5.6	5.4	5.2	5.0	4.2			4
6	9.2	8.9	8.5	8.2	7.9	7.6	6.2			6
8	12.4	12.0	11.5	11.1	10.6	10.2	8.4			8
10	15.7	15.2	14.6	14.1	13.5	13.0	10.6	10.0	14.4	10
12	19.1	18.5	17.8	17.2	16.4	15.8	12.8	12.2	17.4	12
14	22.5	21.8	21.0	20.3	19.5	18.8	15.1	14.6	20.5	14
16	26.1	25.3	24.3	23.5	22.6	21.8	17.3	17.0	23.6	16
18	29.7	28.8	27.7	26.8	25.7	24.8	19.6	19.4	26.8	18
20	33.4	32.4	31.2	30.2	29.0	28.0	22.0	22.0	30.0	20
22	37.2	36.1	34.8	33.7	32.3	31.2	24.4	24.6	33.3	22
24	41.0	39.8	38.4	37.2	35.8	34.6	26.9	27.5	36.6	24
26	45.0	43.7	42.1	40.8	39.3	37.9	29.1	30.2	39.9	26
28	49.0	47.6	45.9	44.5	42.8	41.4	31.6	33.0	43.3	28
30		51.6	49.8	48.3	46.5	45.0	34.3	36.0	46.8	30
32		55.7	53.8	52.2	50.2	48.6	36.8	39.0	50.3	32
34		59.8	57.8	56.1	54.1	52.4	39.4	42.2	53.9	34
36			62.0	60.1	57.9	56.2	41.8	45.4	57.5	36
38			66.1	64.2	61.9	60.0	44.5	48.6	61.1	38
40			70.4	68.4	66.0	64.0	47.2	52.0	64.8	40
42			74.8	72.7	70.1	68.0	50.0		68.5	42
44			79.2	77.0	74.4	72.2	52.8		72.3	44
46				81.4	78.7	76.4	55.2		76.2	46
48				85.9	83.0	80.6	58.0		80.0	48
50				90.5	87.5	85.0	61.0		84.0	50

the perforation formulas for good projectiles against good plates and yet are able to determine but poorly the effect of the same projectiles on inferior plates. But this is the practical problem which is of great interest, and in order to approach its solution, but one way seems to present itsself to us,—to examine all the experiments and to deduce suitable formulas to represent the mean conditions.

For this purpose we have calculated with the principal existing formulas (15 to 20, section 2), the velocities which our projectiles must have in order to pierce wrought iron armor of 10, 20, ... cm., and have taken the mean of these results. Then, considering these means as experimental data, we have sought an empirical formula which will represent them all, and this is what we have succeeded in accomplishing with all desirable approximation. (See formulas 37 and 38, section 3).

A similar method was followed with formulas for the various

E_f, the energy, determined from experiment, for another plate of same thickness but with a projectile of caliber a_1 which is deformed by it, we can place

$$E_f = \frac{\mu}{\mu_1} E,$$

μ and μ_1 being two constant co-efficients characteristic, one of the plate and the other of the projectile; therefore, if the plate alone or the projectile alone is varied and E_f is obtained by experiment, we can deduce μ and μ_1 respectively. But this method is only applicable between narrow limits or such that $\frac{\mu}{\mu_1}$ differs but little from unity, because when, for example, μ_1 is large, it means that the work done on the projectile is predominant and that E_1 and E_2 must be studied separately. This fact, to which reference has already been made, is clearly shown by the experiments made with Harveyized plates; the latter generally break the projectiles, but if we succeed in preventing this rupture by providing the projectile with a cap, we find that the same plate is reduced to the condition of the homogeneous ones.

On the basis of this conception Vallier proposes the following general formula:

$$pv^2 = \frac{\mu}{\mu_1} \, 2000 \, a^2{}_1 \, s \, 10^{0.012 \, (s - a_1)}$$

and furnishes the following values for the characteristics:

$\mu = 0.84$ for wrought iron plates; $\mu = 1$ for the soft steel plates of Creusot; $\mu = 0.92$ for compound plates; $\mu = 1.25$ for nickel steel plates; $\mu = 1.885 - 0.014\,s$ for the first Harveyized plates; $\mu = 2.356 - 0.0175s$ for the Harveyized plates of the Krupp and Carnegie type (at the end of 1897); $\mu_1 > 0.6$ and < 0.7 for cast iron projectiles; $\mu_1 > 0.7$ and < 1 for deformable steel projectiles; $\mu_1 = 1$ for indeformable projectiles; $\mu_1 = 1.5$ for capped projectiles.

Although the values of μ given relate to tested plates, they can yet be but approximate and provisional; it appears, moreover, that they vary with s, and this is explained by observing, that the increment which must be given to the perforation energy to overcome a hardened plate does not increase with the increase in thickness in proportion to the original resistance of the plate. Our formulas (see sec. 3b) not only give prominence to this fact, but they also show the advantages to be obtained by attacking hardened plates with projectiles not only of great velocity, but also of great mass.

And here, apropos of our formula, it is important to observe, incidentally that, for steel plates or nickel steel plates, not Harveyized, they exhibit an important fact, viz.: that the relations between the thickness s_f of wrought iron corresponding to a given thickness s_a of steel are not constant, but increase with s_a, because the quality of a wrought iron plate diminishes with its thickness.

types of steel plates (see formulas 21 to 35, next section), but instead of deducing new formulas from the results, we have found it more practical to establish quite simple relations which permit the determination of the thickness of iron plates equivalent to a given steel plate. This thickness being determined we calculate the velocity of perforation with the formula for wrought iron plates. (See section 3-b).

2. SOME KNOWN PERFORATION FORMULAS.

Before presenting the new formulas we have brought together, in the following table, those from which they have been deduced and which are among the best known.

In these formulas we assume that the projectiles strike the plate normally, (the axis of the projectile being perpendicular to the surface of the plate at the instant of striking) and that the notation and units of measure are as follows:

$$\lambda_1 = \frac{pv^2}{2000\, g\, \pi\, a_1},$$

= energy in meter-tons per cm. of circumstance of projectile;

$$\lambda_2 = \frac{pv^2}{2000\, \frac{g\, \pi\, a_1^2}{4}},$$

= energy in meter-tons per sq. cm. of rt. section of projectile;

$$\lambda_3 = \frac{pv^2}{2000\, \frac{g\, \pi\, a_1^3}{6}},$$

= energy in meter-tons per cu. cm. of spherical shot of same caliber as projectile;

$$E = \frac{pv^2}{2000\, g}$$

= total energy in meter-tons;

p = weight of projectile in kilograms;

a_1 = caliber in cm.;

v = component of striking velocity in meters per second;

s = thickness of plate in cm.

The formulas are as valuable for shells as for solid shot, provided the former are not broken too soon and the fuse is conveniently delayed, or the bursting of the shell is so timed as to utilize to the best advantage the effects of the bursting charge. In calculating the effests of shells, Vallier proposed to add to the energy E of projectiles, the potential energy μH of the charge, in which μ is the weight of the bursting charge and

$H = 320000$ for powder,
$H = 440000$ for dry guncotton,
$H = 327000$ for wet guncotton (20 % water),
$H = 634000$ for explosive gelatine,
$H = 362000$ for picric acid.

It may be observed briefly, that the application of the fofmulas requires that the plate be intact at all the parts which unite in the resistance, except for Harveyized plates, in which it suffices that they be intact at the point struck.

3. NEW FORMULAS.

a. WROUGHT IRON PLATES.

$$p\left(\frac{v}{100}\right)^2 = a^1 s^1 \text{ (*)} \qquad (37)$$

in which

$$a^1 = 0.93\,(1 - 0.007\,a_1)\,(1 + 0.05\,a_1)\;;\; s^1 = (1 + 0.04s)\,s \qquad (38)$$

the symbols and units being the same as in the preceding paragraph.

For convenience in calculation, the values of a and s for different values of a and s have been computed and are given in the following table :

a_1	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
a'	13.0	14.3	16.3	18.1	20.0	21.8	23.8	25.8	27.8	29.9	32.0	34.1	36.3	38.6	40.8	43.1	45.5	47.8
a_1	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
a'	50.2	52.4	55.1	57.6	60.0	62.5	65.0	67.6	70.1	72.7	75.2	77.8	80.3	82.9	85.5	88.0	90.6	93.1
s	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
s'	7.4	9.0	10.6	12.2	14.0	15.8	17.8	19.8	21.8	24.0	26.2	28.6	31.0	33.4	36.0	38.6	41.4	44.2
s	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
s'	47.0	50.0	53.0	56.2	59.4	62.6	66.0	69.4	73.0	76.6	80.2	84.0	87.8	91.8	95.8	99.8	104.0	108.2
s	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
s'	112.6	117.0	121.4	126.0	130.6	135.4	140.1	145.0	150.0	155.0	160.2	165.4	170.6	176.0	181.4	187.0	192.6	198.2
s	60	61	62	63	64	65	66	67	68	69	70							
s'	204.0	209.8	215.8	221.8	227.8	234.0	240.2	246.6	253.0	259.4	266.0							

By the aid of this table and with a calculting ruler, we readily solve formula (37) ; for those, however, not familiar with this most useful instrument, we propose the use of an abacus because we hold that the employment of the abacus should be extended to the calculation of all practical problems, especially of ballistics.

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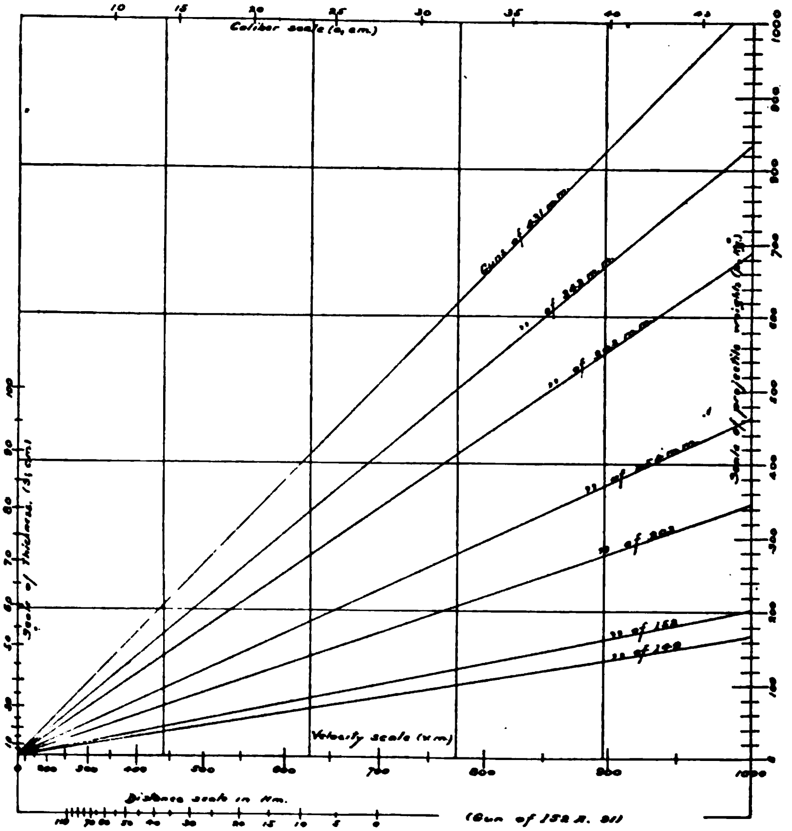
*This formula, like every other, is of no value beyond $s = 68$ cm., because beyond that, lacking experimental data, we cannot obtain formulas which give reliable results.

The solution of (37) with respect to any one of the variables entering it may be reduced to the determination of a fourth proportional. An abacus for the determination of such fourth proportional may be readily constructed as follows: Upon a sheet of cross section paper (see figure) construct a square of 50 cm. on a side, and then construct the following scales on its sides:

PERFORATION ABACUS.



Velocity scale (v)—Divide the lower horizontal side of the square into 100 equal parts and, beginning at the left, mark the points corresponding to the numbers

$$\left(\frac{v}{100}\right)^2 = \frac{0.1^2}{}; \quad \left(\frac{v}{100}\right)^2 = 1.2^2; \quad \ldots \text{ to } \left(\frac{v}{100}\right)^2 = \frac{10^2}{},$$

designating such points, however, as

$$\left(\frac{v}{100}\right) = 0.1; \quad \ldots\ldots\ldots 10.$$

Caliber Scale (a_1)—Divide the upper horizontal side of the square into 100 equal parts and, beginning at the left, mark the points corresponding to the values of a' determined from the preceding table for values of $a_1 = 10$; $= 11$; . . . designating such points, however, as values of a_1.

Scale of Weights (p)—Divide the right vertical side of the square into 1000 equal parts beginning at the bottom.

Scale of thickness (s)—Divide the left vertical side of the square into 1000 equal parts and, beginning at the bottom, mark the points corresponding to the values of s' determined from the preceding table for values of $s_1 = 6$; $= 7$; . . designating such points, however, as values of s.

Finally, one end of a thread is secured at the lower left hand corner of the square and the abacus is ready for use.

The following examples illustrate the use of the abacus:

1. Given a_1, p and s to find v.

By means of the cross section lines, note the point of intersection of the vertical line passing through a_1 (caliber scale) and the horizontal line passing through p (scale of weights). Stretch the thread so as to pass through this point and note where it intersects the horizontal line passing through s (scale of thickness). The vertical line passing through this last point of intersection will intersect the velocity scale at the point desired.

2. Given a, p and v to find s.

Note the point ($a_1 p$) and stretch the thread so as to pass through this point as before, noting where the thread cuts the vertical passing through v. The horizontal passing through this last point will intersect the scale of thickness in the point desired.

This research can be simplified for our guns by drawing a series of right lines from the lower left hand vertex of the square through the points ($a_1 p$) relative to the same guns. It is moreover, necessary to draw, under the velocity scale, as many scales of distances as may be necessary to represent the different cases for each gun. For this purpose we again construct velocity scales upon so many parallel right lines, noting, that if for a certain gun v, v_1, v_2, are the velocities at the distance 0, 100, 200, ... the points graduated for the give velocities are designated by their corresponding distances.* This construction is repeated for all guns and thus all practical problems can be easily solved as follows:

---

*As an illustration, this construction is made in the figure for but one piece,—gun of 152 A. 91 (charge 1).

3. Which of our guns will perforate an armor plate of thickness s and at what distance?

Draw a horizontal line through s and prolong it till it intersects the right line of the maximum gun; through this point of intersection draw a vertical line and prolong it till intersects the scale of distances of the same gun. If this last intersection takes place at a distance greater than zero perforation is possible and the distance is that designated by the scale. We proceed in a similar manner with the other guns.

4. What is the greatest thickness of armor which can be perforated at a distance X with a given gun?

Draw a vertical line through the distance X (a reading on the distance scale of the gun under consideration) and prolong it till it intersects the right line corresponding to the same gun; through this point of intersection draw a horizontal line and prolong it till it meets the scale of thickness. This last point of intersection will give thickness s desired.

b. STEEL PLATES.

The thickness s_f in cm. of wrought iron which corresponds to a thickness s_a in cm. of steel plates.

(39) Steel plate of Schneider

$$s_f = (1.02 + 0.004 s_a)\, s_a.$$

(40) Compound plates

$$s_f = (0.9 + 0.01 s_a)\, s_a.$$

(41) Nickel steel plates

$$s_f \left[(1.11 + 0.01\, s_a) + 0.0011\, (43.1 = a_1) \right] s_a.$$

(42) Harveyized plates (the first products)

$$s_f \left[1.56\, (1 - 0.006 s_a) + 0.014\, (43.1 - a_1) \right] s_a.$$

(43) Harveyized plates, improved, (towards the end of 1897.)

$$s_f \left[2.06\, (1 - 0.006 s_a) + 0.014\, (43.1 - a_1) \right] s_a.$$

(44) Harveyized plates, the last product (1899)

$$s_f \left[2.367\, (1 - 0.006 s_a) + 0.014\, (43.1 - a_1) \right] s_a{}^{*}.$$

(45) Harveyized plates, capped projectiles

$$s_f = (1.38 + 0.006 s_a)\, s_a.$$

---

[*] The formulas for Harveyized plates take the general form

$$s_f = [k\, (1 - 0.006 s_a) + 0.014\, (43.1 - a_1)\, s_a$$

and the increments of the co-efficient k show the progress successively made in these plates. This co-efficient is therefore a characteristic of the plate and must be taken into consideration in the tests and in the study of new plates.

All these formulas are very easy to calculate, but for convenience we furnish the values of s' deduced from them, in the following table :

By the aid of this table every problem is rapidly solved, thus :

1. Given s_a, the thickness of a given type of steel plate, to find v.

Deduce from the table s_f, the equivalent thickness of the wrought iron plate, and then determine the velocity v in the manner indicated.

2. Given the velocity v, to determine s_a, the thickness of a given type of steel plate. Deduce s_f in the manner already indicated, then from the table, deduce s_a, the thickness of the equivalent steel plate, of the type under consideration.

No other indications are necessary for the solution of any other problem, whatsoever ; it is important, however, to observe that the formulas for Harveyized plates are particularly valuable for plates of mean thickness, (i. e. from 13 to 25 cm.) or within the limits of thickness generally employed, such plates deriving the greatest benefits from the hardening of their external surfaces.

C. RONCA, Captain in the Navy.

[Translated by First Lieutenant F. E. Harris, 3d Artillery.]

THE DRAGON BALLOON.*

BY A. VON PARSEVAL.

Printed through courtesy of Chief Signal Officer, U. S. Army, who had the translation prepared. Translation revised by us.—EDITOR.

INTRODUCTION.

A trifle more than a hundred years have passed since the invention of air balloons; in spite, however, of many attempts at improvement, the spherical balloon maintains its position in practical use, and the air balloon has to-day, save in immaterial details, the same form and adjustment originally given to it by the inventor. Although the spherical form is undoubtedly the most suitable for balloons suspended, still, for anchored balloons they have such defects that it is surprising that such an imperfect apparatus could have been adopted in the army.

These defects are substantially as follows:

The balloon in a strong wind is pressed to the ground; while the cable takes a slant position in the direction of the wind, so that the requisite elevation can not be reached, while the violent movements often make observations impossible, since it is almost impossible to keep the eyes fixed on any particular point.

Experience has shown, that the ordinary anchored-balloons, used in the army, are impracticable when the velocity of the wind is greater than 33 to 39 feet, and in consequence, 30% of the days of the year the co-operation of the aeronaut division must be given up.

If, in spite of these defects. air balloons have been introduced,

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AUGSBURG, GERMANY,
May 9, 1899.

[*] The Chief Signal Officer,
Washigton,

The expiration of the Parseval-Siegsfeld patent on my dragon balloon, recently adopted, after several years trials by the Aeronautic Corps of the German Army, and introduced in Austria by an order of the War office there, as well as in other states, induces me to call your attention to this important war material.

The peculiar characteristic of the dragon balloon is that in a calm it rises like a round balloon, and in the wind it ascends and stands firm like a kite. Statistics prove that on an average the dragon balloon can be used 70 days out of 100, while the round balloon can only be used 30. Its form enables it to be sent up in a limited space and from behind cover. It can be unpacked, filled and sent up in thirty minutes, and is then ready to send down information. It can carry one observer to a height of 7700 yards, or two to a height of 650 yards; and works in a wind blowing at the rate of 82 feet a second, while the round balloon works only up to 27 feet a second.

Its utility in sea-coast fortifications has been especially demonstrated by actual trial.

(Signed) A. RIEDINGER.

certainly great advantages must be obtained from this means of reconnaissance, and any improvement as regards their stability and greater independence of the wind and weather will be cordially welcomed.

PRINCIPLE OF ACTION AND COMMON CHARACTERISTICS OF THE DRAGON BALLOON.

These considerations led to experiments in the year 1892, resulting in the construction of the dragon balloon, that is to say, of a balloon, which by a kite plane attachment could be raised in the air and, at the same time, be able to resist strong currents of wind. Efforts and researches in this direction had not been lacking before. First of all, a kite plane made of poles and canvass was attached to the round balloon. In a succeeding attempt (by Herr Rodeck) the kite plane constituted an ingenious flattening of the balloon itself.

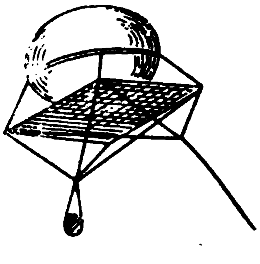


FIG. 1.

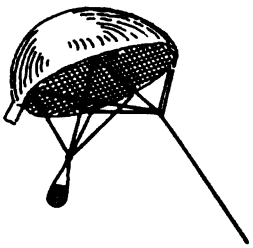


FIG. 2.

All of these attempts failed for this reason: they required an extensive frame work construction. In a strong wind the movements of a balloon are violent and a beating on the ground, during inflation and elevation, is often unavoidable, therefore the frame work constituted a real danger for the balloon. In addition the management was made so difficult that most of the experiments were abandoned at the first trial. Therefore the application of an independent kite plane was given up at once. The kite plane must form a constituent part of the balloon. Besides, the balloon must be capable of resisting pressure. That is to say, the balloon must of itself assume the form prescribed by the constructor under the pressure of the entering gases. Each balloon envelope adjusts itself so as to take in the largest practical volume of gas. If the volume in the form chosen for the dragon balloon is not a maximum, the gas endeavors by its pressure to alter the shape of the balloon, and the balloon must be stiffened by means of a more rigid part. This is the case, for example, in the Rodeck scheme. In this, the projected kite plane without stiffening must spring downward, while it must be withdrawn with cords in the inside connected with its upper side. Around the outer edge a number of folds are formed by it. Shapes capable of supporting pressure have a certain rigidity of themselves; so that when they take shape by the pressure of the gas, they offer a more or less considerable resistance to any deformation.

A balloon-form fulfilling these conditions is the elliptical solid. By experiment, a cylinder with semi-spherical ends proved to be the most advantageous shape. The longitudinal axis of the balloon is directed towards the wind current and inclined so as to make an angle of about 50 degrees to the horizontal. The surface of the cylinder forms, in this way, the kite plane, the hemi-spherical ends the head plane. By the former, the balloon is elevated; by the latter, thrown backwards in the direction of the wind.

Both forces act, so that by the running out of the cable the balloon takes a resultant position, such that the forces, in reference to the point P, where the balloon is anchored to the ground, exert equal and opposing momentum pressure.

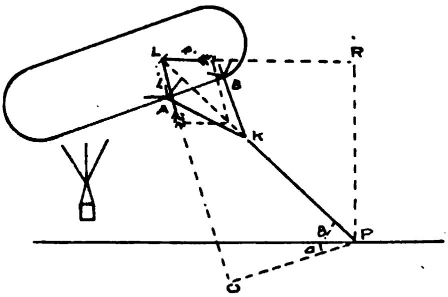


FIG. 3.

Let p_1 denote the horizontal front pressure, p_2 the kite pressure, in a direction perpendicular to the kite plane, that is, perpendicular to the longitudinal axis, we then have the following formula:

$$p_1 \cdot PR = p_2 \cdot OP.$$

The inclination of the cable is determined by these relations. First of all, however, the manner in which the inclined position of the longiludinal axis of the balloon is produced, must be determined. This inclined position is produced, first, by the distribution of the weight in the balloon, then by the nature and manner of the anchoring. The latter point needs farther illustration. From the points A and B, on the left and right of the balloon, cords come out which join together in pairs at some distance. The points of union are united by a stronger cord which passes around a pulley at K. The cable is fastened to this pulley. When the cable changes its adjustment, the point K describes an ellipse with A B as its larger axis. The action upon the balloon is nearly the same as if it were fastened by means of a cable to a single point at the center of A B, and a little above it, around which it can freely revolve. In consequence of this fastening to a point situated under the fore part of the balloon, the wind places the balloon in an oblique position, while the pressure upon the front turns it backwards and downwards until the resulting upward kite-pressure on the bottom surface, a factor of the opposing moment, stops the revolving. When the position of the weight and of the bouyant effort on the one hand, and the force of the wind combined with the anchoring on the other, cause a different inclination of the longitudinal axis, then the balloon places itself so that both pairs of forces act on it with equal and oppositely directed moments. According to the strength of the wind the inclination of the balloon is determined, either more by the forces of the wind or more by the position of the center of gravity. For that reason, it is not practicable to calculate the degree of inclination ; but experiments have shown that it usually amounts to about 20 degrees. When the inclination of the balloon is known the direction of the cable can be approximately estimated, and this is of the greatest interest for practical purposes, because the elevation, which is obtained by the balloon, depends really upon it. The direction of the cable is constantly parallel to the direction of the resultant of the forces operating on the cable. These forces are:

1. The resistance of the balloon to the wind.
2. The buoyant effort of the balloon.
3. The resistance of the cable to the wind.
4. The weight of the cable.

The most important of these influences is the resistance of the balloon to the wind ; for this reason we consider this first, separate from the others, and imagine the balloon made so heavy for this purpose that it has no free bouyant effort, and anchored with such a short cable that the weight of the balloon and the wind resistance of the cable do not really enter into the question, a supposition that may easily be practically realized.

In this case the cable places itself exactly parrallel to the resultant of the wind resistances.

The direction of this resultant we determine from the above equation :

$$p_1 \,.\, PR = p_2 \,.\, PO.$$

Now, as is clearly shown in Figure 3 :

$$PR = PL \sin \beta; \text{ and } PO = PL \cos (\alpha + \beta).$$

By substituting these values in the equation we obtain

$$\tan \beta = \frac{\cos \alpha}{\dfrac{p_1}{p_2} + \sin \alpha}.$$

We can vary the inclination of the longitudinal axis by changing the anchoring and the position of the center of gravity. If we assume their value as known, we must still determine the ratio

$$\frac{p_1}{p_2}.$$

The latter depends on the inclination and the adjustment of the balloon.

In balloons, hitherto built, the ratio of the circular cross-section was to the longitudinal cross-section, that is, front surface : kite plane, as 1 : 3. The reduction co-efficient for the sphere is ⅓, for the cylinder ½ : that shows a reduction of the surface in the ratio of 2 : 9[*]. Now the cylinder axis stands obliquely to the wind. If now we place, according to Loessl, the wind pressure proportional to the sine of the angle struck, we will have the following proportion :

$$p_1 : p_2 = 2 : 9 \,.\, \sin \alpha.$$

It appears, however, that we have rated the front resistance too low. The following table contains the values of the cable angles, calculated from the above formula, by taking different values for the kite angle and for the ratio

$$\frac{p_1}{p_2}$$

---

[*] 1 : 3.
$\frac{1}{3} \times 1 : \frac{1}{2} \times 3 = \frac{1}{3} : \frac{3}{2} = 2 : 9.$

$\frac{P_1}{P_2}$	$\frac{1}{4 \cdot 5 \sin \alpha}$	$\frac{1}{4 \cdot \sin \alpha}$	$\frac{1}{3 \cdot 5 \sin \alpha}$	$\frac{1}{3 \cdot \sin \alpha}$
α	β_1	β_2	β_3	β_4
10	36	31½	28½	25½
15	41½	41	35½	32
20	43½	41	38¾	35½
25	44	42	39½	37
30	42½	41	39	36⅓
35	40½	49	37½	35½

In the experiments, the kite-angle $\alpha = 10°$ to $20°$. The cable-angle was about 30° or 40°. The above calculation agrees, as far as can be ascertained, with the trial results, and approximately with the values for β_2 and β_3.

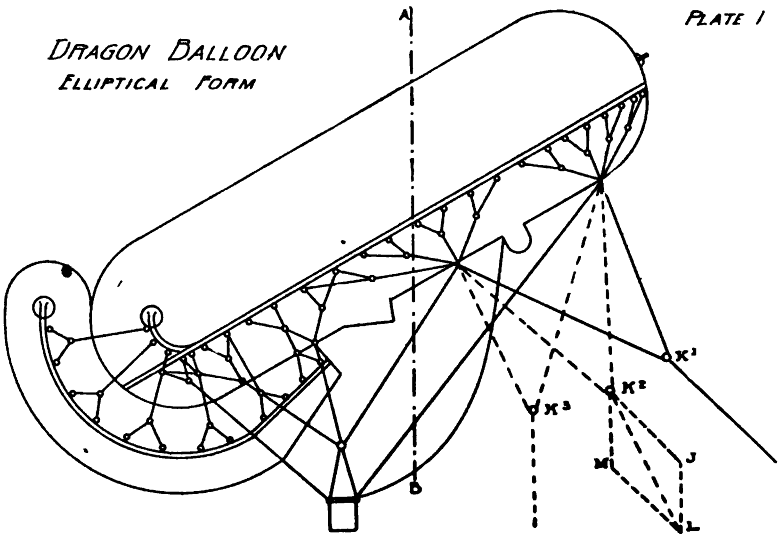
With the increase of the wind, the kite-angle decreases somewhat, and the balloon stands perceptibly lower, as the calculation shows. It is hardly necessary to add anything farther to the above inferences.

The comparison of the calculation with the experiences is obviously difficult for the reason that the cable is only parallel to the direction of the wind-resistance, that is, only takes the above estimated inclination, when:

1. The balloon is exactly balanced, and
2. The weight and the wind resistance of the cable are not appreciable.

If the balloon is not balanced, it swerves either above or below the estimated position of the center of gravity.

Plate 1 shows at K_1 the cable in the position of the center of gravity with ballanced balloon; at K_2 the position of the cable, when the balloon has free bouyant effort; at K_3 the position of the cable when there is no wind, and the balloon has only its own bouyancy. In the position K_2 the vertical line K_2M denotes the bouyant effort; the line K_2J which is parallel to the direction of the cable in K_1 shows the direction of the wind resistance. The direction of the cable is the resultant of both forces in the parallelogram of forces K_2 J L M. Let us assume that the bouyancy is used for raising a long and heavy cable. Suppose the weight of the cable is equal to or less than the bouyant effort; in that case, a vertical power which equals the bouyant effort,



works on the anchoring of the balloon. For, if the cable weight is not sufficient to maintain equilibrium with the bouyant effort, the excess of the bouyant effort is spent on the anchoring point on the ground, and the cable receives, at the top, near the balloon, independent of its length, a vertical tension component, which is equal to the bouyant effort. But if the cable is so long that its weight exceeds the bouyant effort of the balloon,—this happens when a long cable is sent up by means of kite action—the excess of cable weight increases the vertical tension components on the balloon. The inclination of the cable from the balloon is more nearly perpendicular, and the head of the balloon is drawn somewhat down, so that the kite angle becomes smaller. The cable runs therefore with a strong curve to the earth. The angle, under which it touches the ground, gives the direction of the resultant of the forces, which are operative at that point. These forces are, besides the resistance of the balloon to the wind, the bouyant effort and the cable weight, also the resistance of the cable to the wind.

The latter acts perpendicular to the cable, but not uniformly on all its points. For, the pressure of the wind is less upon the less inclined lower parts than upon the upper more nearly vertical parts. The cable resistance can thus be placed equal to a total force, whose resultant acts on a point in the upper half of the cable and is directed obliquely downwards. In the first place this force increases the curving of the cable and causes a more nearly perpendicular inclination of it at the top, and a drawing down of the head of the balloon; besides, it presses the balloon somewhat down. Since it exerts its influence above the middle of the cable, the larger half acts to press down upon the balloon, the other half is taken up at the earth.

Let us consider the balloon farther in the case when the weight of the elevated cable corresponds exactly to the carrying power of the balloon in a calm. In this case, only the resistance of the atmosphere works on the lower end of the cable, since, according to our calculations, the weights are equalized, and a tangent to the cable at its lowest point shows the direction of this resistance. The cable touches this tangent from above and rises the higher above this right line the farther it ascends from its lowest point.

The balloon, of course, always stands *higher* than the tangent indicates, and the feebler the wind is, the higher it stands. In a stronger wind the cable stretches tighter, and the balloon approaches the tangent; with a stronger wind, therefore, it moves back a little.

When the balloon has a greater cable weight to carry than corresponds to the carrying power of the gases, the cable runs from the ground in a more acute angle; under these conditions it extends for a little distance on the ground if the carrying power of the kite action is not sufficient to hold it up. However, it is not possible, in a strong wind, to raise by the kite action a cable weight greater than that which corresponds to the force of the wind, since the balloon is drawn down by it too much in front, and by the decrease of the kite angle is injured in its kite action.

In the experiments, the action of the kite plane realized perfectly the expectations entertained of it; the slow, almost imperceptible manner in which the vertical change in elevation took place was surprising. No vertical oscillation occurs on disturbing the equilibrium. The reason is this: the balloon has an equilibrium position at a cable incline of about 40 degrees, which it approaches closely when the wind blows. As a result the tendency to approach still nearer to the position of equilibrium is small. Besides, vertical movements are suppressed very effectively by the kite plane. For, the kite resistance is lessened by an upward movement and decreased by a downward movement, the motion thereby greatly delayed. This effect is especially noticeable when a sudden gust of wind strikes on the cords with a loud whistling, so that one naturally expects a violent motion of the balloon ; so one is very much surprised, at first, to see how little the dragon balloon is apparently influenced, as the changes of elevation are scarcely perceptible to the inmates.

(To be continued.)

PROFESSIONAL NOTES.

BALLISTICS.

Ballistic Data of the Krupp 15 cm. (5.9 inch) Navy R. F. Gun.

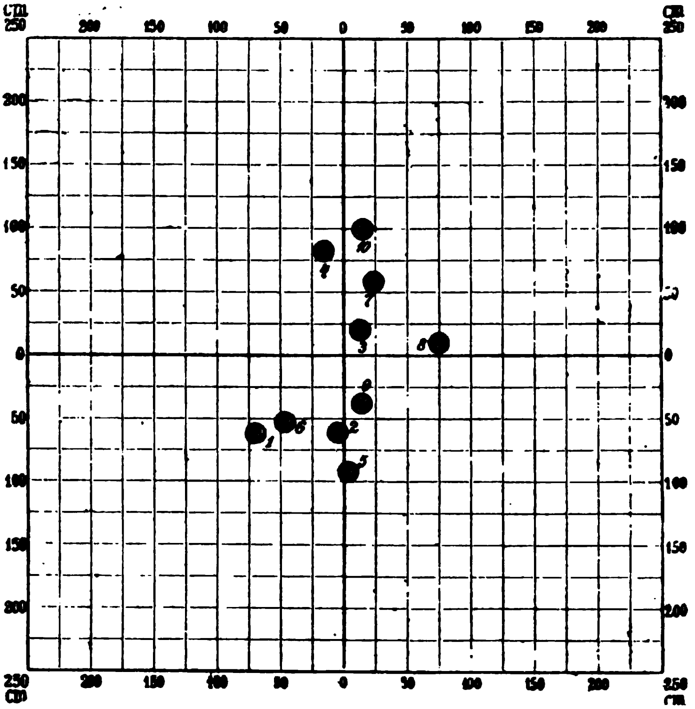
J. CASTNER.

In the following table are given certain data regarding the qualities of the Krupp 15 cm. (5.9 inch) R.F. guns for naval use, taken from the great British publication *Lord Brassey's Naval Annual* and the latest edition of the Austrian *Marine-Almanach.*

GUN.		Weight of Projectile.	Muzzle	
			Velocity.	Energy.
		lbs.	feet.	foot-tons.
Krupp light 15 cm. R.F. gun. C/97.	L/40	112.2	2268	4068
		90.2	2501	
	L/45	112.2	2444	4741
		90.2	2726	
	L/50	112.2	2608	5381
		90.2	2903.5	
Krupp heavy 15 cm. R.F. gun. C/97.	L/40	112.2	2392	4534
		90.2	2667	
	L/45	112.2	2565.6	5216.6
		90.2	2864	
	L/50	112.2	2739	5948
		90.2	3051	
Krupp light 15 cm. R.F. gun. C/99.	L/40	112.2	2437.7	4708
		90.2	2719.8	
	L/45	112.2	2631	5479
		90.2	2936	
	L/50	112.2	2821.5	6299
		90.2	3143	
Krupp heavy 15 cm. R.F. gun. C/99.	L/40	112.2	2592	5315
		90.2	2890	
	L/45	112.2	2772	6102.5
		90.2	3090.5	
	L/50	112.2	2953	6923
		90.2	3294	

There are two projectiles, differing in weight, for these guns, and the lighter must, of course, have the greater muzzle velocity, which also makes its trajectory up to 1650 yards a flatter one than that of the heavier projectile, the advantage of which is that errors in elevation are of less moment. If we assume that the decisive artillery fight at sea will take place within the range of 1650 yards, the use of the lighter projectile will be justified. On the other hand, beyond that range the heavier projectile has a gradually increasing ballistic advantage over the lighter, in consequence of the lower effect of the resistance of the air. According to the weight given to these opposite advantages, the lighter or the heavier projectile will be preferred.

In order not to lose sight of the accuracy and rapidity of the guns here described, in the contemplation of their other excellent qualities above set forth, the accompanying diagram is added, showing the results of an actual firing test at Meppen, February 9, 1895, with a Krupp 15 cm. R.F., L/40, gun, on center-pivot, cradle carriage, and illustrating graphically the continual progress made by the Krupp works. The target was at a range of 2706 yards, and the series of 10 shots was fired at it in 81 seconds.



As seen from the diagram, the 10 shots struck in a rectangle 140 cm. (55 in.) wide, and 190 cm. (75 in.) high; the calculated mean vertical deviation is 58 cm. (22.8 in.), the mean lateral deviation 27.6 cm. (10.9 in.), and the 50% zone would be 98 cm. (38.6 in.) high and 46.6 cm. (18.3 in.) wide.

Although this test was made under favorable conditions of weather and light, still it shows a remarkable degree of accuracy. It speaks well for the excellence of the gun as a machine, for the perfection of the sight and the piece, as well as that of the pointing arrangements and the carriage, admitting as they do of such rapid loading and pointing, and at the same time offering such mobility of the parts and such certainty of action of the arrangements for taking up the recoil, as to make such a result possible. The latter also proves the uniform character of the ammunition, as well of the projectiles (their dimensions and weights) as of the powder charges (their uniformity of action). This target practice is, moreover, an evidence of the training of the gun detachment. It requires a high degree of training to give the eye the necessary quickness and accuracy, and to secure the reqired calmness, decision and self-reliance to bring ten shots, with pauses of only 8 seconds between, at a range of over 1½ miles, into a target space of the size of an ordinary double window! At all events it shows what a good detachment can do with a good gun.

The 15 cm. gun is an interesting example in the application of ballistic principles, of improving, by means of new discoveries and developments, the smaller calibers first before proceeding to the larger.

The following table contains a few data regarding the development of the 15 cm. (formerly the 24-pounder) gun, which speak for themselves.

No.	GUN.	Year.	Weight of Projectile.	Muzzle	
				Velocity.	Energy.
			lbs.	feet.	foot-tons.
1	S. B. 24-pounder	To 1861.	24.2	1739	515
2	Iron Gun	1861	60.2	1178	590.6
3	Steel and Bronze Gun	1864			
4	Long Ring Gun	1872	78	1624	1453
5	L/30	1878	112.2	1657	2175
6	L/35	1882	112.2	1804.5	2579
7	L/35	1889	100	2132.6	3215
8	L/40	1890	100	2231	3517
9	L/40, heavy	1897	112.2	2392	4534
10	L/50, heavy	1897	112.2	2739.6	5948
11	L/40, heavy	1899	112.2	2592	5315
12	L/50, heavy	1899	112.2	2953	6923

If we study this table in connection with the above, we have the entire history of the development of this gun to the present day, and in that way arrive at a correct estimation of what has been accomplished by the Krupp works in this domain.

—Translated by the Editor from *Stahl und Eisen.*

Automatic Sights.

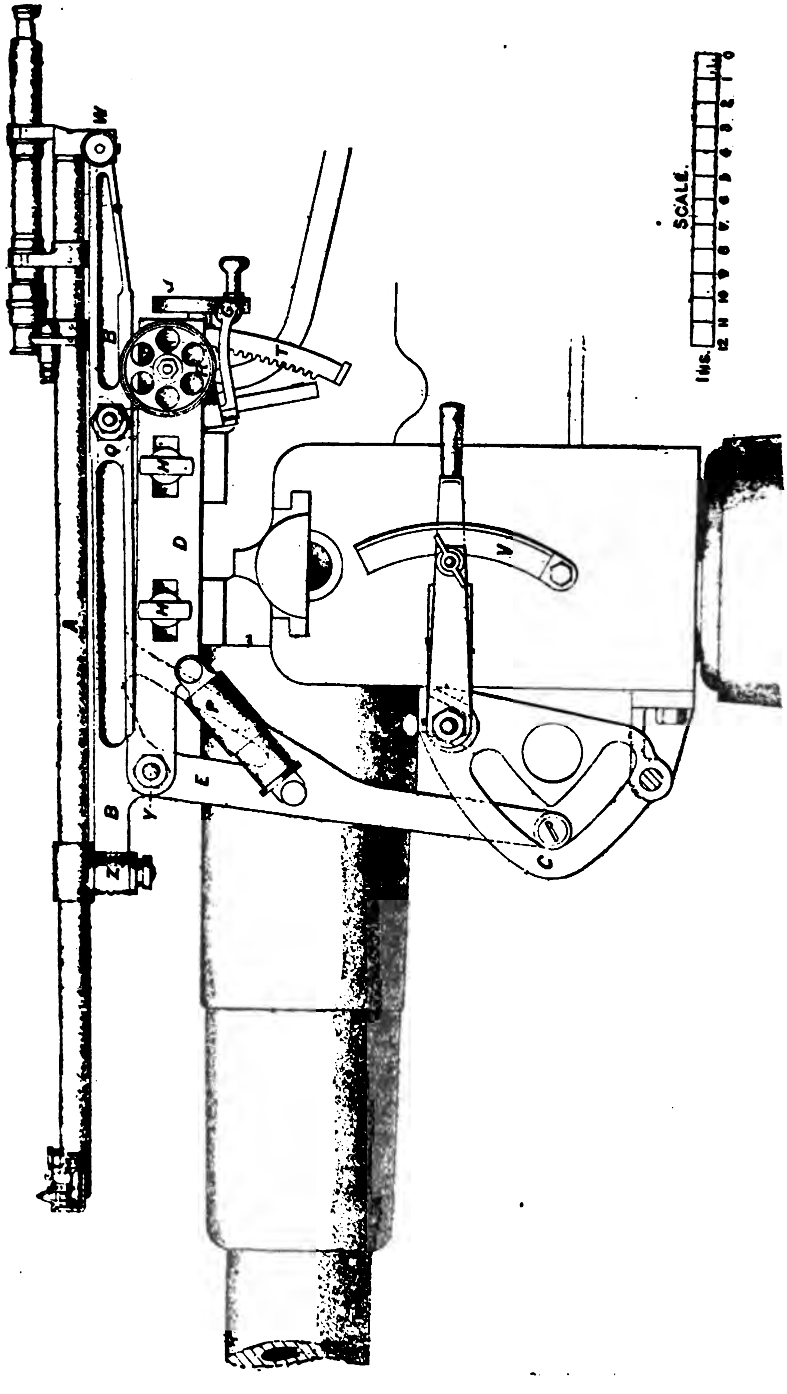
The sketch shows a 12-pounder Q.F. sight, which may be taken as typical. The sights for the various natures being the same in principle though differing in detail.

GENERAL DESCRIPTION.

The sights consist of the following parts:—

1. A sight bar A, carrying sights which can be illuminated, if necessary, at night, and a telescope for use at long ranges or indistinct objects. Deflection is given by the small hand-wheels W, which traverse the sight bar horizontally about the pivot Z. No deflection need be given for drift, as the sight is set at a compensating angle.

2. A radius bar B, to which the sight bar A is pivoted at Z, carries the deflection gear. B is pivoted at Y to a bracket D, which is attached to the cradle of the mounting by eccentric studs H H. Their eccentricity enables the final fine adjustment to be given to the sight on its first fitting to the mounting, and they should not afterwards be disturbed, future adjustments that may be found necessary being given by the eccentric bouche Q, which


W
B
J
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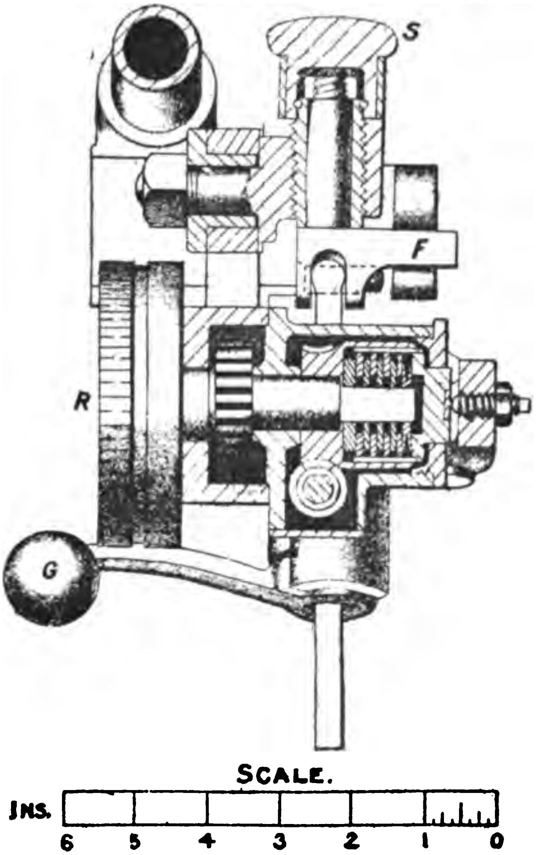
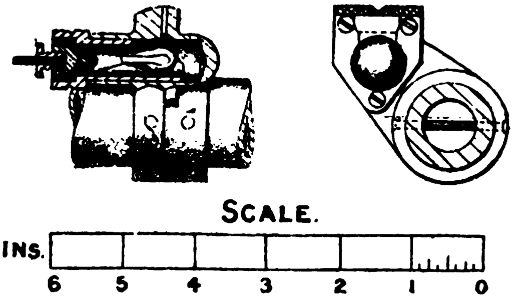
is provided for the purpose. The bracket D carries also the gear by which the sight is moved when used as a bar and drum sight, and also the range drum R.

3. A bent lever E is also carried on the pivot Y. One end of E carries a roller, engaging a cam C attached to the carriage. The other end is forked to receive a latch F, worked by a lever G.





The latch F connects the lever E to the radius bar B, and when the latch engages the fork, the sight is controlled by the cam C, and works automatically. When the latch is disengaged the sight can be used as an ordinary tangent sight.

4. A spring P, in compression, keeps the roller at the end of the lever E in contact with the driving surface of the cam C.

5. One of the studs fixing the cam C to the carriage is eccentric, and can be turned by the lever K to give the correction necessary for height of tide, the proper position of the lever K for different heights of tide being shown on the arc V. When the rise and fall of tide is very small compared to the height of the battery, the lever K is omitted, but the eccentric stud is retained as a means of adjusting the cam.

6. A screw S, which will be found in the sketch above the latch F, is provided to give the correction for the error of the day. Its head is graduated in yards short and yards over. By its means the relative positions of the radius bar B and the lever E can be altered to the extent necessary to compensate for any error observed in the shooting.

7. For use at night, both the fore and tangent sights can be illuminated, the foresight presenting a point of light at the top of the acorn, and the tangent sight a luminous V. To effect this, incandescent electric lamps are carried in the sight blocks. The current should be turned off when not required, so as not to exhaust the battery.

THE PRINCIPLE OF THE SIGHT.

The sight combines a depression range finder with a bar and drum sight. Suppose the elevating gear be worked so that the radius bar B is depressed from a horizontal position until the sights bear upon the water-line of an object, the drum R will be turned by the rack T, which is attached to the radius bar B, to an extent depending upon the angle of depression, which in its turn depends on the range. If then the drum R be correctly graduated, we have a complete range finder.

It now remains to secure that the elevation corresponding to the range be given to the gun.

This is effected by connecting the radius bar B by means of the latch F to the lever E, whose other end works in the cam C on the carriage. The sight can then be moved only by raising or lowering the breech of the gun, and the cam C is so shaped that the angle between the axis of the gun and the line of sight is always equal to the proper angle of elevation for the range. From this it will be seen that the cam must be cut to suit the height of the gun above the sea, and each cam will thus be special to the site for which it is made.*

METHOD OF USE.

1. As an automatic sight :—

The sight being in adjustment, and the latch F engaged in the fork of the lever E, set the tide lever K to the proper height of tide, and the error of the day screw S to zero. Give the estimated deflection. Align the sights on the water-line of the object by working the elevating and traversing gear of the gun.

To correct errors in shooting, turn the error of the day screw S to the graduation corresponding to the number of yards short or over observed, and make the usual correction for direction on the deflection scale.

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* See *Journal U. S. Artillery*, Vol. XII, p. 33.

2. As a bar and drum sight:—

The sights are only suitable for automatic use when firing at the water-line of objects. Should it be desired to utilize the automatic sight as a range-finder, to fire at the upper works or tops of a ship, the water-line should first be laid on (and if it be the first round of the day's practice, ranged on as in 1). The latch F should then be thrown out of gear by the lever G, and the sights aligned on the desired point by working the elevating and if necessary the traversing gear of the gun. If the ship be moving it will be necessary to throw the latch F in again from time to time, and to lay on the water-line again in order to re-set the sights to the altered range.

It will be seen from what has been said about the principle of the sight, that its accuracy as a range finder falls off rapidly at long ranges, especially if the sight of the battery be low, as in that case the angle of depression on which the action of the sight depends varies but slightly with the range at long ranges.

For these longer ranges the latch F should be thrown out of its fork by the lever G, which at the same time throws into gear the hand wheel J, which works the rack T and range drum R. By means of this hand wheel J, the range drum R may be set to any required range as given by P.F. or D.R.F., and the gun can then be laid as with ordinary tangent sights.

ADJUSTMENTS.

In the first place the mounting must traverse truly in a horizontal plane. This may be tested by placing a large clinometer on the gun and traversing the mounting round. The bubble should not move.

Means will be provided for correcting the level of mountings fitted with automatic sights. The mounting being levelled, the following tests may be applied:—

1. Mechanical test:—

Turn the error of the day screw S and the tide lever K to Zero, and throw the latch F into its fork. Place a large clinometer on the gun, and lay it at the prescribed angle. Then place the clinometer on the upper surface of the radius bar B, and over the portion where the directions are inscribed, and see that its reading is the corresponding angle. The angles referred to will be found engraved on the upper surface of the radius bar B. If the reading is not correct, slack the clamping nut and turn the eccentric Q until the correct reading is obtained. None of the other eccentric studs should be used for this purpose.

Finally, see that the range shown on the range drum of the sight (when set as above) is the prescribed range laid down by the directions inscribed on the upper surface of the radius bar. If not, slack the set screws on the outer circumference of the range drum and turn the scale till it reads the prescribed range.

2. Optical test:—

The telescope being focussed on a distant point, should be rotated in its supports. If this shifts the intersection of the cross wires or pointer from the object, the usual collimation adjustment should be applied. *Vide* Handbook for D.R.F.

The ordinary sights on the bar may be compared with the telescope by laying on a distant object, and should be in agreement. As it is possible that individual layers may vary, thus introducing a personal error between gun sights and telescope, vertical adjustment is given to the foresight to enable sights and telescope to be adjusted to each other to suit the gun layer.

As manufactured, the gun sights and telescope are in adjustment with the foresight screwed down home, and this should be regarded as the normal position of the foresight, correction being made only to suit the individual gun layer should time permit of the gun being carefully laid on to a distant target.

If such correction has been made, and the layer should be disabled, the foresight should preferably be screwed home failing time to make a test.

CARE AND PRESERVATION.

When not in use, the sight bar A with all its fittings attached should be removed and placed in a dry store. Its removal can be effected by slackening a screw which will be found under the pivot Z, and disconnecting the leads for the night sights.

As the efficiency of the sight depends upon the accuracy of the cam C, special care should be taken that this suffers no damage. It should on no account be polished, and should be kept free from grit.

All parts should be kept lightly smeared with anti-corrosive grease when not in use, but care should be taken that the hole at the tip of the foresight and the glass V of the hind sight are kept clear, and do not become plugged with grease or dirt.

The lamp holders and lamps must be kept clean and clear of grease, as also the holes into which they fit. There must be electric contact between lamp holders and sight bar, and if this is dirty the lamps will not burn well.

In throwing the latch F into gear, care should be taken that it is opposite the jaws in the bar E, in order to avoid injury to the parts.

INSTRUCTIONS REGARDING LAYING.

An automatic sight is one which, being properly adjusted and connected with the gun, (or cradle) and mounting, is dependent in such a way on the movement of the gun that by elevating and traversing the latter till the sights are aligned on any spot on the sea level, the gun is necessarily so laid that its projectile should strike that spot.

The principle is dependent on the solution of the triangle formed by the sea level as the base, the height of the gun above sea level as the perpendicular, and the line from sights to water line of target as the third side.

The angle of depression of the line of sight varies with (and in fact indicates) the range of the target. The angle of quadrant elevation of the gun varies with the angle of depression of the line of sight, and the amount of elevation given to the gun can be made automatically dependent on the amount of depression given to the sights.

It follows that the sight can be used as a range-finder, and this, with combined automatic and tangent sights, may be useful if it is desired to fire at ships' tops, &c. The gun must be first laid automatically at the water line of the ship. This will indicate the range to the ship on the drum of the sights, and will set them at the proper angle of elevation. The automatic gear being then disconnected, the gun can be laid on the top in the ordinary way, the sights retaining the elevation which has been automatically given to them.

The pattern of automatic sight adopted for the 12-pounder Q.F. gun requires a height of not less than 20 feet. With a height of 25 feet it is accurate up to 1,200 yards, and with greater heights to longer ranges.

The sights, so far as the mechanism is concerned, can be made perfectly accurate, and this accuracy is capable of being tested without firing, but the results obtainable do not depend only on the accuracy of the sight; they are limited by what can reasonably be expected from a layer.

Inaccuracy on the part of a layer is of much more importance in the case of an automatic sight than in that of a tangent sight *used at a known range.* For example, with a 12-pounder Q.F. gun, mounted 25 feet above the sea, an error of one minute in the adjustment of the automatic sight bar would cause an error of range of only 25 yards at 800 yards, but the effect of the same error would be 52 yards at 1,200 yards range, and 200 yards at 2,000 yards range, while a corresponding error in the setting of a tangent bar would be about 20 yards in all three cases.*

The reason for this is that, in the latter case, the angular motion of the line of sight is precisely the same as that of the axis of the gun, while in automatic laying any variation in the angle of depression of the sights (or range finding angle) necessitates a greater variation (the amount of increase depending on the range) in the quadrant elevation of the gun, so that except in the case of short ranges, or very lofty sights, the axis of the gun moves through a far greater angle than the line of sight. For example, under the conditions above quoted (12-pounder Q.F. gun at a height of 25 feet), it is found that an error of one minute, either in the sight or made by the gun layer, at a range of 2,000 yards, causes an error of 22 minutes in the elevation of the gun.

—*Garrison Artillery Drill*, London, 1899.

ARTILLERY MATERIAL.

Our Guns and Their Use in War.

Our guns have been the text for many attacks on our authorities in the daily papers. If the charges are all well grounded, we are certainly badly served. Our object, now, will be to deal with them fairly and carefully. At times, no doubt, we have been scandalously behindhand, and what has happened before is possible again. Further, the fact is that the world's progress in war material is so rapid that the greatest care is needed not to fall behind in some branch, as may be seen in the history of almost all Powers. At the celebrated Krupp trials at Meppen in 1879 we gave considerable offence by advocating breech-loading steel guns as far better than our composite coil muzzle-loaders. So obsolete do those seem now, that we almost hesitate to trust our memory as we write the words. On the other hand, in 1891 England had taken an enormous stride beyond any other Powers in the introduction of quick-fire armaments. New type long guns and slow powder we had long before this worked out for ourselves, these two being in a fireat measure due to the work of Sir Andrew Noble. Krupp certainly had already obtained such results at Meppen in 1879 that it is difficult to believe that he had not independently developed his long new type pieces. As to the heavier quick-firing guns, it is only necessary to consult lists of armaments from about 1890 to 1894 to see how completely England led in quick-firing armaments. In armor originally France was first, we followed closely, and then for some time seemed to be leading in both armor and armor-piercing shot, Whitworth steel projectiles being for some time the best. Then steel armor came in, while we were obstinately trying to keep to compound plates, and dropping lamentably behind in armor-piercing projectiles. At length, however, we adopted Harvey and Krupp process plates in succession, and then came, partly from good judgment and partly by good fortune, a phase of development in the structure of our ships, owing to which at the present time we have an element of superiority that would tell more heavily than has ever been put forward, though there is no reason why it should not now be pointed out, as the the conditions which brought it about are ending. It came in the following way: Sir W. White's designs for our battleships provided 6-inch quick-firing guns protected by 6-inch armor. Foreign ships had 3-inch to 5-inch in almost all cases. When the hard face came in it happened that 6-inch was about the best thickness to suit the hardening treatment, which caused thinner plates to warp. Hence in many cases an English man-of-war would engage an enemy with her own heavy quick-firing guns behind 6-inch hard-faced armor, while those of her enemy were only behind 3-inch, 4-inch, or 5-inch of ordinary steel. Consequently, the British ship could perforate with armor-piercing shells as well as shot, while her foe's quick-firing guns could perforate with nothing.

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* See *Journal U. S. Artillery*, Vol. XII, p. 193; Vol. XIII, pp. 19, 62.

To return, however, to our guns and their fittings. In carriages England has always been good, and Rendel and Vavasseur's designs have been closely copied abroad. In powder we have been respectable. Germany certainly seemed to have got smokeless powder into use on a large scale before us; but our tropical service called for special care, and when it came in our cordite seemed in most respects very good, and we do not know that foreign powders escape its faults; but of this more by-and-bye. On the whole, since we gave up our muzzle-loading guns, we have always been well to the front, though not leading in all respects. No nation has escaped being occasionally left behind. Any foreign power might have been caught by us at one time with their quick-firing armaments behindhand, and the enterprising United States authorities until quite recently had very insignificant armaments of them, and actually went to war with Spain with black powder several years after it had been superseded by smokeless powder in European armaments.

The general lesson to be gathered from all this, however, is that any of us may be caught napping if not kept sharply on the watch, and public agitation has often been the means of rousing us, although not always perfectly directed. It is well, then, now to consider the condition of our ordnance, taking first the classes that most interest us, because they are in action in South Africa, that is, our field guns, our guns of position, and our siege guns.

A list of our breech-loading service ordnance shows for field guns a 12-pounder, a 15-pounder, and a 5-inch howitzer as the ordinary equipment of our horse and field artillery batteries. These are the guns that were first despatched to the war, omitting for the present the mountain gun. The 12 and 15-pounder guns fire shrapnel only, the howitzer common (lyddite) and shrapnel shell. Our readers will bear us out in saying that their story so far may be summed up very much in the following way:—At the first operations, before the investment of Ladysmith, the practice and behavior of the artillery was reported to be admirable, and to have greatly disconcerted our enemy. At the passage of the Modder River, Lord Methuen, in praising all arms, specially mentioned the artillery. Next came Colenso, when nine guns were lost; and the statement was made that our guns were out-ranged by those of the Boers, which has led to the hot attacks and correspondence carried on in the daily papers. The actual loss of our guns was due not to artillery, but musketry fire, that swept down men and horses; it may, however, be urged that their deficiency in range caused them to push forward, where they suffered, and that had their range been longer this would have been unnecessary. We doubt if complete information exists on this point; but as we have before said, it is quite conceivable that Boer guns were engaged against them with a superior range. This was undoubtedly the case at Ladysmith, at all events, for the Boers had established themselves in their positions for some weeks or months to come, and would naturally bring up guns which were too heavy to move freely and perform evolutions in the field. They appear, indeed, to be stronger relatively in guns of position than in field pieces, for it may be noticed that our artillery has done best when mobility was an element involved, and when the operations most nearly partook of the character of field movements and fighting; that is to say, when the Boers were first met in Lord Methuen's first advance. Indeed, at Belmont we hear of the Boers having but two guns to oppose us. Now that the war has settled into a contest between men in trenched positions, mobility is of little use, and their heavier pieces, which never got far south, are just the guns needed. In these they seem strong, and these, no doubt, out-range ordinary field pieces. This brings us to the conclusion that, while the field guns were naturally first sent out, guns of position should have followed as quickly as possible. How quickly depends on the means at disposal and the presence of other needs.

It will, however, be objected that in saying that the Boers had siege guns and guns of position nearer at hand, and brought them up against our field guns, we are shirking the objection that has been urged, that our field guns are heavier and yet inferior in range, not to guns of position, but to the field pieces of other Powers. With regard to this we can hardly do better than reproduce a small table which we gave in our issue of December 22nd, the figures of which are mainly taken from an admirable paper, contributed by Captain Kenyon, now in the department of the Director-General of Ordnance. It will be seen that Austria has a field gun which professes to give a high muzzle velocity, namely, 1800 foot-seconds, but which is at present experimental. This can hardly fail to be a piece of considerable weight, especially as the gun is made partly of bronze. Supposing, however, for the sake of argument, that this gun turns out more successful than we think possible, it is still in an experimental stage, so that Austria, in our position, would have sent into the field, not this gun, but its predecessor. What France is doing we do not at present know. She appears to be experimenting, like Austria, though she has some new guns brought into the service. Russia has a heavier projectile,, but far lower velocity. Germany most closely resembles us. Her gun's projectile's velocity is less, but its weight is greater. Practically, our

Elements of Power in English and Foreign New Type Field Guns.

Nation.	Caliber of bore in inches.	Weight of projectile. lb.	Muzzle velocity, ft.-sec.	Muzzle energy ft.-tons,	Weight of load behind team, cwt.	Range sighted up to, in yards.
Germany	3.03	15	1525	241.8	33	5468
France	2.95		at present kept secret.			
Russia	3.42	15.2	1355	193.5	—	—
Austria	3.07	13.2	1800	experimental.		
England	3.00	14.06	1574	241.4	32¼	5500
		Horse Artillery.				
England	3.00	12.5	1553	—	31	5200
		Field Howitzer.				
England	5.00	50	782	—	—	4900*
Vickers	2.57	12.5	1575	215.0	33	5000

* (at 42 deg. 24 min. elevation). † A mountain gun.

powers are nearly the same. The German weight behind theirs is a little more than ours. The figures in this table, then, being correct, no one can call us behind the continental Powers, and it is difficult to believe that the Boers obtained from Krupp guns much better than those made for his own Government.

Captain Holcroft, late of the Transvaal States Artillery, has given in a lecture at St. George's Hall, Langham-place, an account of the ordnance possessed by the Transvaal in 1898. He sums their guns up as follows :—

	14	6-inch guns (obtained from Creusot) firing 94 lb. shells.
	6	5.9-inch guns (Krupp) firing 90 lb. shells.
	10	5-inch guns (Krupp).
	5	Nordenfelt (taken from Dr. Jamieson).
	10	7-pounders. } obtained from England.
	8	12-pounders. } obtained from England.
	20	72 m.m. guns (Krupp)
	73	Total.
Also	2	37 m.m. of the latest Maxim-Nordenfelt.
	10	37 m.m. Hotchkiss.
	30	0.307-inch bore "Maxims and Martini."

Captain Holcroft ought to speak with authority, but he must, we think, be depending on memory or be inaccurately reported, for certainly the statements as printed are inaccurate.

We are told that two Creusot guns are called "Long Toms," each of which weighed 14 tons, measured just short of 14 feet in length, carried a 94-lb. projectile, and had a range of 10 miles. How impossible these elements are may be seen from the fact that the Creusot gun most nearly agreeing with this that we can find in the *Naval Annual* is one discharging an 88.2 lb, shell with a 5.91 in. (15 c.m.) bore, length 22.2 feet, and weight 5.71 tons, not 14 tons. There is a gun weighing 13.9 tons, but its shell weighs 242.5 lb., and it cannot be the piece intended, because the two "Long Toms" are apparently from the fourteen 6-inch Creusot guns firing the same 94-lb. shells. Krupp's 6-inch guns firing 90-lb. shells are doubtless his 15 c.m. pieces, and the 5-inch are his 13 c.m. pieces. The 37 m.m. Maxim and Hotchkiss must be the machine guns that have taken a prominent part in the earlier engagements. They discharge shells weighing about 1¼ lb. each. Taking the last as furnishing even a general idea of the Boer guns, it is a curius one. Let us see which are the field guns that are said to "out-range" our own. The 6-inch and 5-inch are guns of position, and very heavy ones, 5¾ tons and 4⅓ tons respectively. So we are left to find these field guns, which we ought to have acquired ourselves, among the rest, that is, the 12 and 7-pounders bought from England, the Nordenfelt guns taken from Jamieson, or the 72 m.m. Krupp guns. The gun most nearly resembling these, to be found in Krupp's list, is a 75 m.m. piece, with an 11½ lb. shell, weighing perhaps nearly 17 cwt. This piece would certainly command a much longer range than our 6 cwt., 7 cwt. or even 12 cwt. field guns. It is, in fact, a heavy gun of position, bearing out what we have said of the part taken by Boer guns in war.

There remains, however, one important question that we must notice, namely, the projectiles and fuzes. Germany, unlike England, uses a kind of common shell as well as shrapnel with her field guns proper. This common shell contains a high explosive, and it bursts into a great many fragments which spread widely, enabling them to search behind cover. We have issued shrapnel only, which we believe the Germans have, like us, proved to be the best projectile, and that generally used; and instead of providing our 3-inch guns with common shell, which have little capacity and little explosive power, we introduced howitzers firing common shells of much greater capacity and power, whose curved trajectory and low velocity searched behind cover much better than shells from the 3-inch gun. The power of these we proved in the Soudan, and the introduction of howitzers appears to us to be thoroughly good. Nevertheless, we think that some common shell should also have been issued to our 3-inch field guns. Not only had these pieces shrapnel only, but their fuzes were only long enough for a range of 4100 yards, so that to strike an enemy's gun effectually, or to attack at ranges of over 4100 yards, the projectile must be fired without fuze almost as a shot. This sounds as if the charge of a short range and being over-ranged by the enemy, if not due to the gun, remained practically supported by the limit of fuse. We think a longer fuze desirable, and a fuze has been now adopted to give 6000 yards range; but, nevertheless, we do not believe that our guns suffered from being out-ranged by Boer field fiuns, because at the longer ranges the firing of small guns becomes very inaccurate, shrapnel very feeble, and we have heard of shells which fell without bursting, and shrapnel bullets falling in a harmless sort of heap. We could perform that at long ranges if we wished it. We do not expect much ourselves from an increased length of fuze. A small proportion of common shells, especially with percussion fuzes, for 3-inch as well as larger bores, we should be glad to see; but we may observe that it is extremely difficult to make melinite or lyddite act in shells of small capacity. The Boers have, however, injured us so far as occasional loss of life and destruction of buildings are concerned, by shells from larger and heavier guns, so that it was a great matter to have even our two 4.7-inch naval guns brought into Ladysmith.

We were delighted to get these guns. They came at the time and place when and where we needed them. This, however, does not show that we ought to have heavier guns instead of our ordinary field pieces. The 4.7-inch, or even the heavy 12 cwt. 12-pounders could not have taken the place and done the work performed by our field battery, both in moving forward to attack and in covering the retreat from Glencoe to Ladysmith. Had our objectors been writing in Pretoria, would they not have had reason to cry out that, in first contact with the British, the Boers' guns were never present; that at Belmont, even, they had only two, and that it was difficult to see how their heavier metal told in their favor; that they had never disabled one British gun; that their infantry accomplished everything, and, while they were met constantly by the British field guns, got little support from their own? Now for a few words on the use of field gun fire.

In the open field horizontal shrapnel is by far the most effective projectile: well directed it would sweep away men in columns wholesale, bnt against trenches it can effect but little. We believe that it has been found best to open the shell fifty yards in front of the trench, so as to send showers of bullets along the crest; if men show themselves they may no doubt suffer, but if they turn round and sit with their backs against the parapet they are safe. Shrapnel thus fired may thus no doubt keep down the enemy's fire while troops advance to capture the trench, but when they get within perhaps 300 yards shrapnel must cease, or they would sweep down their own men. This is the critical moment when the defenders spring up and pour in the fire from their magazines, now unimpeded by smoke, giving a hail of well-directed bullets, such as may make it impossible for any living man to pass through. The consideration of curved shrapnel fire must be reserved, with heavy guns, for another article.

—*The Engineer*, February 2, 1900.

Elswick Naval Mountings.

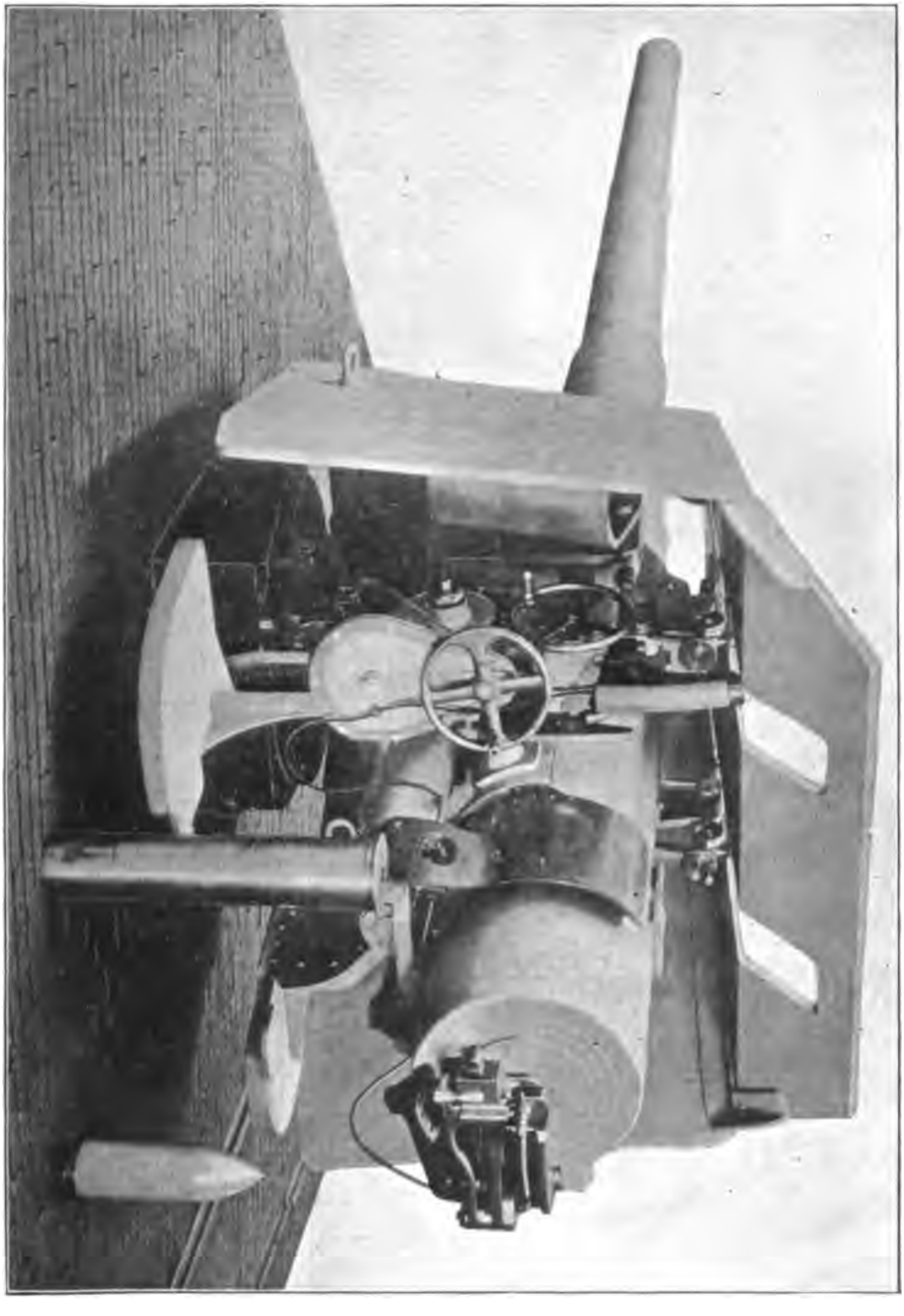
6-inch Q.F. Gun.

In continuance of our description of modern Elswick guns, we revert for the moment to those of 6-inch calibre. The illustration shows the 6-inch quick-firing gun, which may at present be said to be the most important gun existing in our Navy. The system differs from the last mentioned in the fact that training is wholly performed by hand. The gun depicted has a shield, which is only used when not mounted in a casemate.

In 1894, owing to difficulties in manufacture caused by a strike of moulders, the cradles ceased to be made of cast steel, a forged steel patern coming in which is lighter and more satisfactory.

To give an idea of what can be practically done at sea, some results of target practice may be mentioned which were obtained. The conditions of firing are that each gun's crew has three minutes to score what they can at chosen ranges, beginning at 2200 yards, diminishing to 1600, and finally increasing to 2200 yards again. In H.M.S. *Blake* the best gun's crew fired eighteen rounds, hitting the target fifteen times, while the total number of the rounds fired by the ten guns was 148, the target being hit 110 times. H.M.S. *Royal Arthur* did nearly as well, the best guns having fired eighteen rounds, striking the target fourteen times.

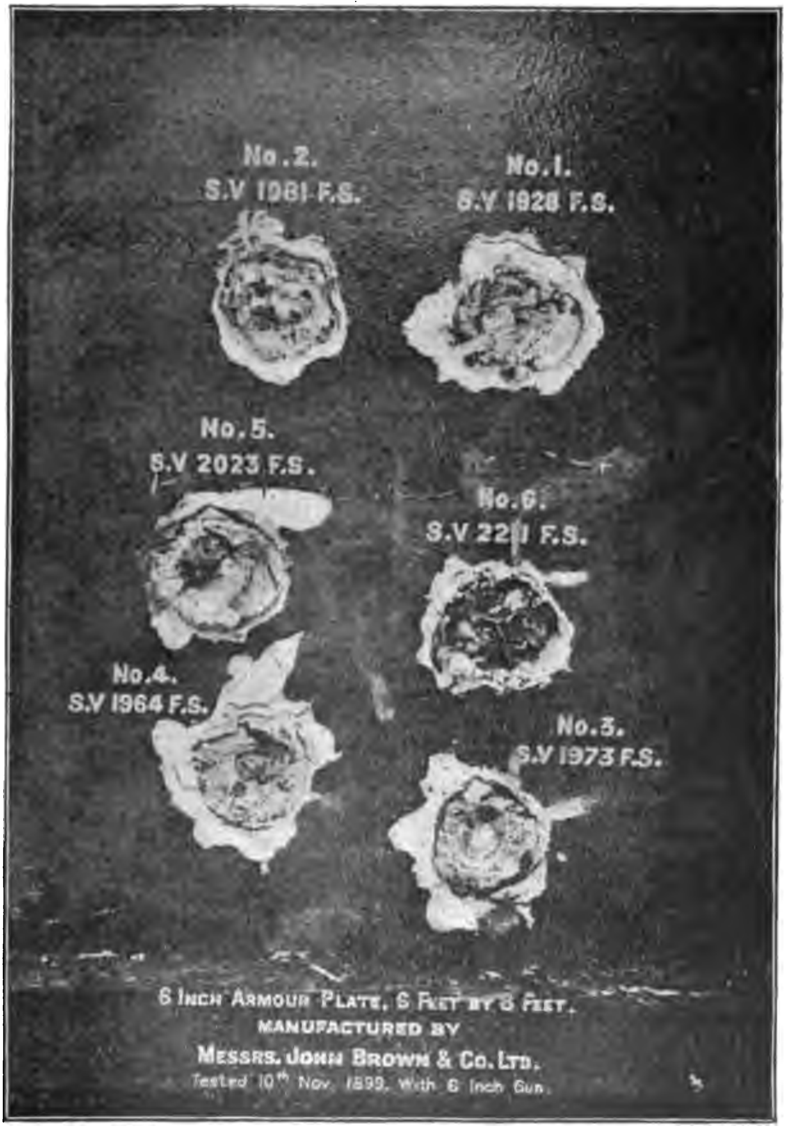
—*The Engineer*, February 2, 1900.



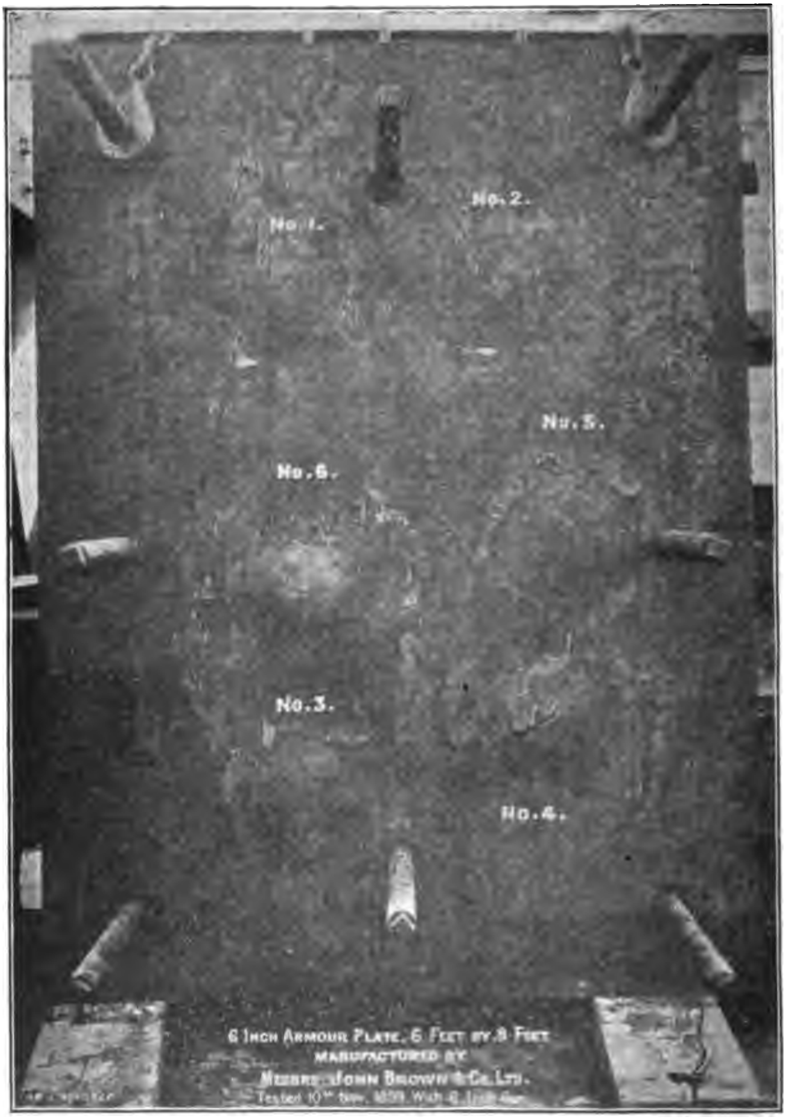
Armor Plate Firing Test.

We have received the following account of a very excellent result obtained with a plate of J. Brown and Co., made on their modified Krupp process:—

On November 10th, 1899, a firing trial of one of John Brown and Co.'s armor plates was made at the proving grounds of Armstrong, Whitworth, and Co., Limited, in the presence of Captain C. J. Mörch, Commander Moe, and Lieutenant von der Lippe, of the Royal Norwegian Navy, and representatives of the shipbuilders and armor plate manufacturers.



6 Inch Armour Plate, 6 Feet by 8 Feet.
Manufactured by
Messrs. John Brown & Co. Ltd.
Tested 10th Nov. 1899. With 6 Inch Gun.


No. 1.
No. 2.
No. 5.
No. 6.
No. 3.
No. 4.
6 Inch Armour Plate, 6 Feet by 8 Feet
Manufactured by
Messrs. John Brown & Co. Ltd.
Tested 10th Nov. 1899. With 6 Inch Gun.

The plate was one selected by Captain Mörch from a lot manufactured for the armor of two Norwegian battleships building in Elswick shipyard, and was subsequently reduced to dimensions for the prescribed test, of which the conditions were as follows:—Plate, 8 feet by 6 feet by 5.9 inches; backing 24 inches oak and 1¼ inches skin plate; bolts, eight of 2½ inches diameter; number of rounds, four; projectiles, steel armor-piercing, 6 inches diameter and 100 pounds weight; striking velocity, 1960 feet per second; striking energy 2664 foot-tons; calculated perforation, 13.4 inches of iron. The plate was expected to resist this attack without being perforated or seriously cracked.

The projectiles provided by the Norwegian authorities were made at the Elswick Works on the celebrated Wheeler-Stirling process, and, as they weighed 102½ pounds each, the specified velocity was reduced to 1936 foot-seconds, to compensate for the extra weight. The striking energy thus remained unaltered at 2664 foot-tons, and the calculated perforation became 14 inches of iron.

The four prescribed rounds having been easily defeated, and no cracks being developed in the plate, the trial was pronounced highly satisfactory, and the whole of the armor represented was approved in respect of ballistic resistance. To obtain some idea, however, of the ultimate defensive power of the armor, the attack was supplemented by two extra rounds at increased velocities, which also failed either to perforate or produce any cracks in the plate except a few superficial hair lines in the face. The following are the particulars of the results of each round :—

Number of round	Projectile.		Striking velocity.	Striking energy.	Penetration.	Height of bulge at back.
	Calibre.	Weight.				
	in.	lb.	Foot-secs.	Foot-tons.	in.	in.
1	6	102½	1902	2571.4	3⅝ (measured)	1¼
2	6	102½	1958	2725.1	3¾ (estimated)	1⅜
3	6	102½	1948	2697.3	3⅝ "	1¼
4	6	102½	1940	2675.1	4¼ "	1⅝*

* Destruction of shot's point apparently slightly delayed.
The above constituted the acceptance test.

5	6	102½	1997	2834 6	4⅛ (estimated)	1½
6	6	102¾	2182	3392.5	5 "	2⅜

All the projectiles were smashed to pieces. Except in the case of the first round, exact measurement of penetration was prevented by fragments of shot lodged in the indent. The last round was capable of piercing 17 inches of wrought iron by Tresidder's formula, that is, 2.7 times the thickness of the plate fired at; or, calculating on the continental method, as by de Marre's formula, a 6-inch shot of 102¾ pounds would require 1340 foot-seconds velocity to perforate 5.9 inches of "ordinary steel," and the actual velocity of the last round was 2182 foot seconds, the coefficient is $\frac{2182}{1340}=1.629$.

There is one interesting feature in this trial to be noticed, namely, that the bulge made at the back by No. 4 round has in its centre a star-shaped tear, showing that the shot is in a measure boring a hole which would be completed by sector-shaped pieces being torn and displaced outwards from the shot point. In the other five rounds apparently boring has been wholly defeated, and the shot point so far flattened as to be compelled to punch out a disc to get through the plate, entailing much more energy. It may be seen that No. 4 round happened to have less energy than all except No. 1, yet it may be questioned if its perforation would not be completed with less work than any of the other rounds. It is, in fact, an example of the case which, as we have pointed out before now, occurs in certain rare instances, where the blow is so truly normal to the plate surface, and the projectile so good, that the point, instead of being lost, retains much of its sharpness. Probably a capped shot would behave very nearly like this No. 4 projectile. If plates were really struck normally on service, as may be seen here, caps should certainly be adopted. This plate has a very high figure of merit, and it may be questioned if perforation could be achieved with much less energy than would imply three times the resistance of wrought iron. Success is not sufficiently nearly reached to enable an estimate to be formed, but we call attention to the point, because it is desirable to get a factor for Krupp process armor. Three times wrought iron appears high, but in one of the very few cases when a Krupp has been just perforated the figure was 2.95.

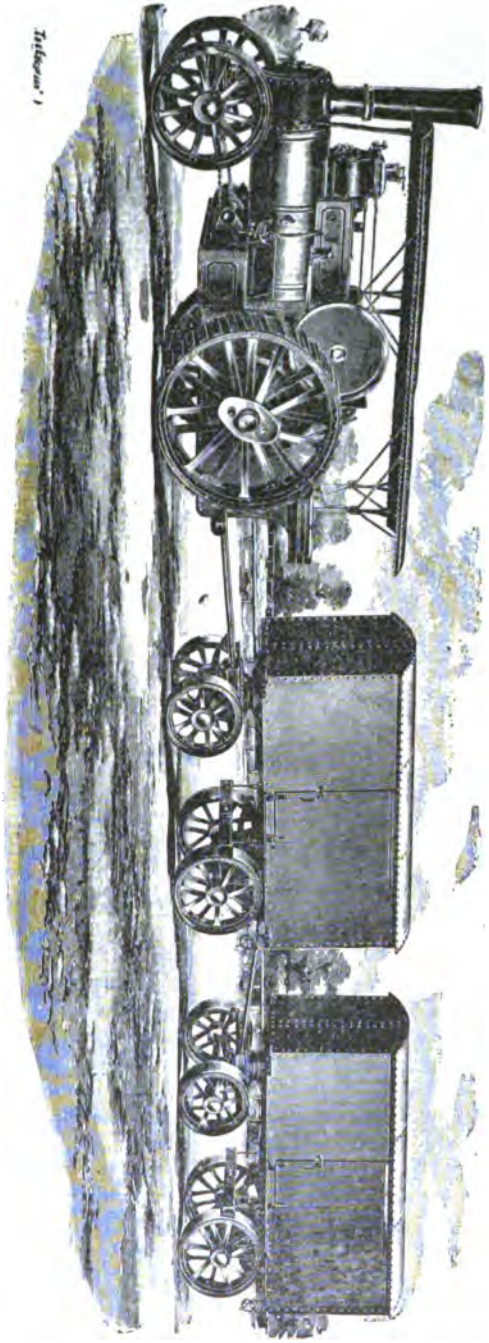
—*The Engineer*, February 2, 1900.

TRANSPORTATION.

Compound Road Locomotives for the War-Office.

The part which the traction engine has to play in warfare is as yet in a large measure undecided. Up to the present, however, the work that it has been given to do it has done well, and may be taken as an earnest of its capabilities of developing unsuspected sources of usefulness. We have already, in a recent issue, illustrated the engine and wagons made by one firm for use in South Africa, and here we give an engraving of an engine and train constructed by Aveling and Porter, Limited, of Rochester. The engine is a special compound road locomotive, with the cylinders side by side. They are 7½ inch and 12 inch diameter, and the stroke is 12 inches. The crank shafts and intermediate shafts are of steel, and the best crucible steel castings are used for all the gearing. The indicated horse-power of this engine is 75, and it travels at three or six miles an hour. The boiler and fire-box are both of steel, and lap-welded tubes are used. The working pressure is 150 pounds, and the test pressure—for Government requirements—is twice that. The grate area is seven square feet, and the total heating surface is 195 square feet. The water capacity is 409 gallons. The wheels are of extra strength. They are made of wrought iron, and are 7 feet 6 inches diameter by 2 feet wide. The steering wheels are 4 feet 6 inches by 1 foot. An unusually large coal bunker and water tanks have been arranged, and a special brake acting on the inside of the rims of both driving wheels has been fitted. The engine has also a double water elevator for lifting and forcing with hoses; a governor, so that it may be used for driving a dynamo for searchlight; and a winding drum with 250 yards of steel wire rope.

The special traction wagons which are shown with the engine are constructed of mild steel and wrought iron, and are mounted on strong laminated springs. The under carriage is of steel, the wheels, like those of the engine, of wrought iron; they are 12 inches wide, and are plated with extra tires. The bodies are entirely of steel, both frame and plating; the latter is ⅛-inch thick. There are sliding doors on each side, and powerful screw brakes and spring draw-bars. In concluding this description, we may be permitted



Traction Engine and Steel Cars.

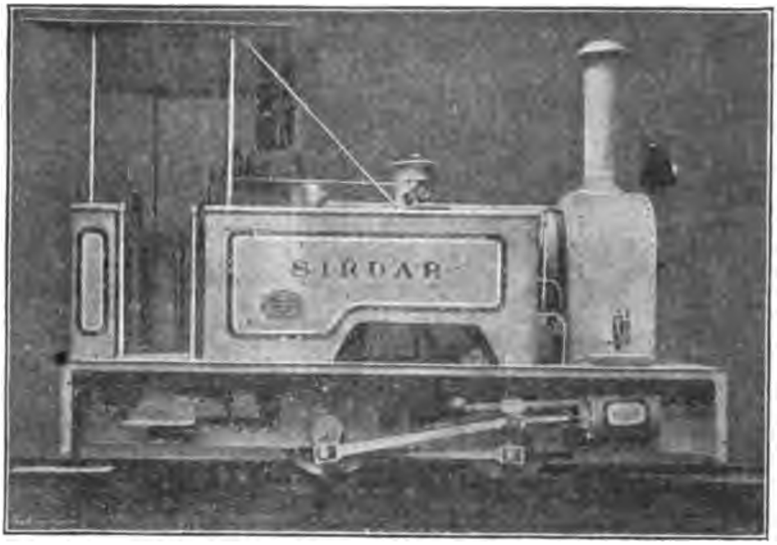
to quote Mr. Bennet Burleigh's letter to the *Daily Telegraph* dated January 2d, which shows that the traction engine at that time was making itself useful.

"Weather permitting, the half-score or so of strong Aldershot traction engines, which have at last been detrained here and at Chieveley, will do much towards making General Buller's army compact and mobile. Without them the troops would require an astounding length of ox and mule wagons. The despised ox wagon is slow and sure. Its infallible drawbacks are that it occupies a considerable length of road, requires much guarding, with many attendants, and can only be depended upon to haul not more than 600 pounds. Nay, more, if the teams are to carry their own forage, the power of hauling is limited to something like fifty miles. Were the army entirely dependent upon trek ox-wagons, the 1660 of them, the inconsiderable number for conveying the munitions of this army, would stretch along several miles of road. It will be another affair if the dry weather continues and any great use can be made of the traction engines. They require few attendants, don't jib, and each can easily haul twelve tons. Yesterday and to-day these wheeling Puffing Billies have been running to and fro transporting stores from the railway siding to the respective brigade camps, one of which, Hart's, is two miles away. They leisurely descend into spruits, roll across, and wheel up stiff long climbs like flies walking up a wall. Tacked on to one of the big guns they should, weather permitting, shift it rapidly from place to place, nor are they quite helpless when the ground has been soaked with rain. Clip-irons are attached to the rims of the broad wheels, and these dig into the firmer soil, and the steamer rolls forward, leaving a wake like a ploughed field. On the flat dry veldt the steamers trip along at a brisk eight miles an hour."

—*The Engineer*, January 26, 1900.

Siege Train for the War.

We are enabled to illustrate the trucks and locomotives forming the siege train which was suppled to the War-office by Kerr, Stuart, and Co., Limited, last November. It will be remembered that a very smart piece of work was done in connection with this train, which it may be interesting to recall to our readers' memory. The inquiry reached the firm's London office on Monday, November 13th. Practically nothing required was actually complete at the date of the inquiry. The order for two narrow-gauge locomotives, five miles of straight and one mile of curved railway, with steel sleepers, &c., thirty sets of points and crossings, two sets of diamond crossover roads, twenty-four four-wheeled wagons to carry 3½ tons each, fifteen bogie wagons to carry six tons each, and two six-ton bogie brake wagons, was given on Saturday, Novemder 18th, to the company's head office in London, and the majority of the work, including both locomotives, was inspected and passed by the War-office on the Wednesday following, November 22nd, four days later, including the Sunday. The remainder was completed and despatched well within the contract period, which was ten working days. This was a remarkably short space of time, and we have investigated the matter in order to find out how it was managed, making a special journey to the company's works at Stoke for the purpose. As soon as the inquiry was received the company satisfied itself that such material as it had not got in stock could be at once procured from other firms. It was in an excellent position to carry



out such an order. Besides the work which it carries out itself, it has large contracts on hand with other firms. These, by arrangement with its clients, who co-operated in a most laudable manner, it was arranged might be drawn upon. For instance, the rails and sleepers sent out were manufactured at Mosbay, and were in such a condition that they could be despatched without delay.

All the points and crossings were manufactured in the time at the company's works, and the mile of curved railway was bent to template, there being no less than three different curvatures. The company had in stock all of the channel irons required for the construction of the four-wheeled wagons and a few chilled cast iron wheels. Some of the channels for the bogie wagons were also in stock. The balance of these were obtained from a merchant's stock in Liverpool. Owing to fog during Saturday and Sunday, November 18th and 19th, these got delayed *en route* to the company's works at Stoke, and the North Staffordshire Railway took special pains by making inquiries along the line to find them and take them on to Stoke. The springs were manufactured at Sheffield and the chilled cast iron wheels in Edinburgh. At each place the firm had a representative, who, as and when the material was completed, despatched it by passenger train to the works. Special trucks were attached to the passenger express trains for the purpose. There was also a representative in Liverpool arranging for the reception and loading of the finished material on board the ship which was to convey it to Cape Town. Kerr, Stuart, and Co. are loud in their praises, not only of the North Staffordshire Railway Company, but of all the sub-contractors, for the whole-hearted manner in which they all dealt with the work.

The locomotives sent, of which there were two, were originally destined for the Egyptian Government, and had been on order some little time. They were, however, not in a very advanced state. The frame plates, although in stock when the inquiry was received, had not been treated by the firm in any way. On November 15th, however, in anticipation of the order being given, the work of erection was commenced. They were actually despatched from the works on the 22nd—a week later—after having been run for two days in presence of War-office authorities. Some of the men engaged on this part of the order voluntarily worked for three days and three nights without stopping. The tests included running the locomotives on a special railway curved to 60ft. radius, with full steam pressure. The War-office also insisted on a hydraulic pressure test of the boilers of 280 lb. on the square inch—the general working pressure being only 140 lb. We are informed that they were gauged during this test, and showed little deflection and absolutely no permanent set when the pressure was removed. We are enabled to give a photograph of one of the engines. They were intended, as already mentioned, for the Egyptian Government, and, of course, permission had to be obtained to divert them. The class of locomotive is exactly the same as has been supplied in considerable numbers, not only to the Egyptian Government, but also to those of the Cape and Russia. Details of the locomotives are as follows:—The cylinders are 6-inch in diameter, and have a 10-inch stroke. The gauge is 5 feet. The diameter of the wheels, of which there are four, all coupled, is 24 inches, and the wheel base is 3 feet 6 inches. The diameter of the axles is 3⅞ inches, and the journals are 3¼ inches by 5 inches. There are thirty-six 1¼-inch tubes in the boiler, and the fire-box is of copper. There are 83.5 square feet of heating surface in the tubes, and 16.5 square feet in the fire box, making a total of 100 square feet. The grate area is 3.33 square feet. There are water tanks at the sides coming nearly to the top of the boiler. These hold 90 gallons. The weight when empty is 5 tons 12 cwt. The cylinders are placed outside, and there is a light metal awning over the driving platform. Most fortunately this type of locomotive is one which has lately been ordered in considerable numbers for constructional work abroad, and in consequence of this nearly all the parts were in a more or less forward condition. Even allowing for this, however, it was a wonderful piece of work to get them out in the time.

Fig. 1 shows the four-wheeled wagons. They had a platform 11 feet by 4 feet 10 inches. The wheel base was 5 feet 6 inches, and the wheels 16 inches in diameter. They carried 3½ tons. They were fitted with a brake on one wheel.

Fig. 2 shows the bogie wagons. These were 16 feet long inside the end posts and 4 feet wide overall. They are to carry six tons, and will be used for the transport of guns. One wheel of each bogie is braked. The wagons are in reality simply flat-platformed trucks limited to 4 feet wide, so as to accommodate the gun carriages, and provided with removable check posts. It was necessary that the platforms should be no more than 4 feet wide, so that gun carriages could be placed on them, the wheels of these hanging down on either side. The makers knew that the platforms must only be 4 feet wide, but being unaware at the time the order was given for what purpose the wagons were going to be used, they had put the sockets for the check posts outside of the wagon frames. When the War-officials came to inspect the work this was at once discovered and orders given for the sockets to be put on the inside of the channels. Naturally this alteration took some little time, and rendered it all the more remarkable that the order was executed within the prescribed limits.

In addition to the foregoing there were also two 6-ton bogie brake wagons.

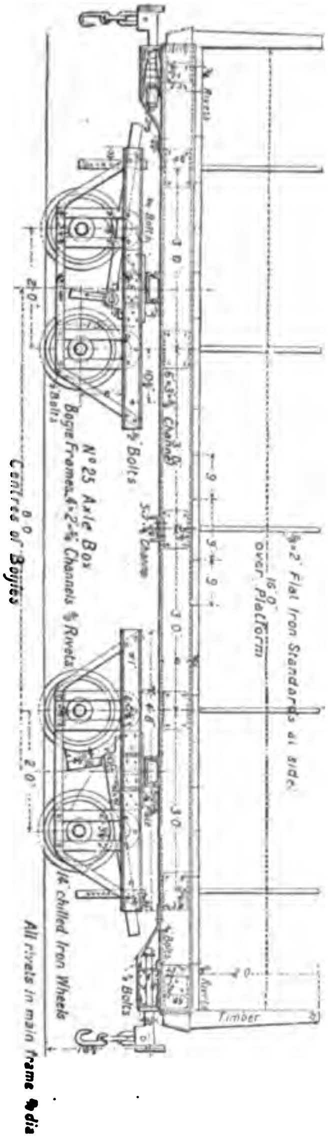


Fig. 2—6-TON BOGIE WAGON

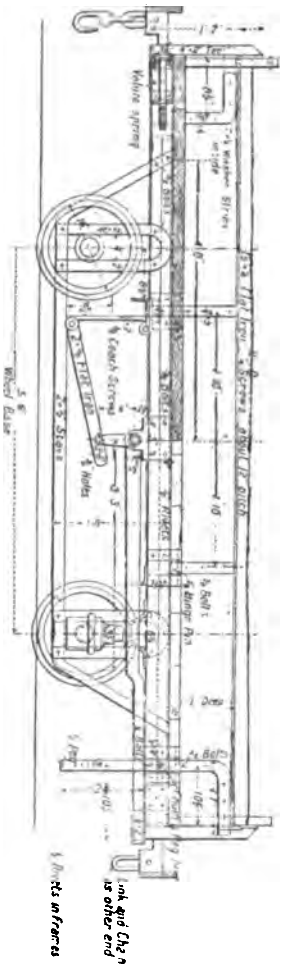


Fig. 1—3½-TON FOUR WHEELED WAGON

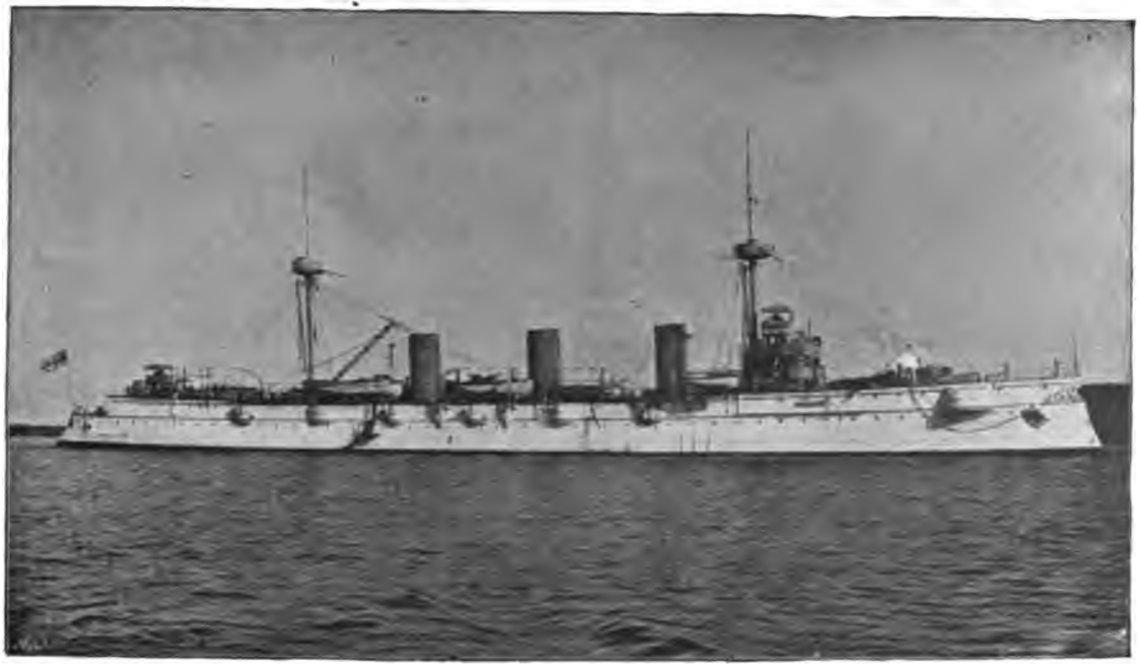
These were provided with a brake to each of the eight wheels; and with regard to brakes we may mention that only after the order was given was the exact form of brake to be used decided upon. Naturally under these circumstances all the brakes had to be manufactured throughout and stock articles could not be resorted to. The brakes are applied by means of hand wheels at the end of the wagons. The bogie brake wagons were of similar design to the foregoing bogie wagons, and are presumably meant for the same purpose, as here again the check posts are not put outside the frame work.

The rails supplied are of the Vignolles section, and weigh 20 pounds per yard. They are in 21 feet lengths. The sleepers are of channelled steel of trough section, the underside of the tops being provided with a thickening piece in the centre. For the fixing of the rails two tongues are punched at either end of the sleepers where the rails are to come. These are so arranged that the tongues will project over the base of the rail on each side when this is placed in position. Keying is performed by means of small steel wedges.
—*The Engineer*, January 19, 1900.

WARSHIPS AND TORPEDO BOATS.

Germany.

The *Kaiserin Augusta* is a first-class cruiser, launched at Kiel in 1892. She is built of steel, sheathed, her length 393 feet, beam 40 feet, 3 inches, draught 23 feet. She has only deck armor (3½ inches). Her armament consists of twelve 5.9-inch guns, eight 3.4-inch Q.F., two light guns, and eight machine guns, with five torpedo tubes. Her speed is 22.5 knots, and her complement 427 men.



German First Class Cruiser *Kaiserin Augusta.*

BOOK REVIEWS.

Nautisch-Technisches Woerterbuch der Marine. Ergaenzung zum ersten Bande. Julius Heinz, K. u. K. Linieschiffs-Capitaen. 1900 Pola: Mittheilungen aus dem Gebiete des Seewesens. Pp. 872. Price, bound, $6.00.

This volume is a supplement to Volume I of Dabovich's work of the same title, issued about fifteen years ago, and was rendered necessary by the progress in the various branches of nautical science during that time, carrying with it, as it does, not only the introduction of many new terms, but also bringing into closer relationship with naval science certain other branches of science, not before related, and therefore necessitating the introduction of terms belonging to such branches.

The Navy section of the Austrian War Department ordered the compilation of this work about five years ago, and it has just been completed. It is in four languages, viz: German, Italian, French and English, and comprises all the additions to the literature of this subject during the past twenty years, including the new developments in electricity, the use of carrier pigeons, bridge-building, the chemistry of explosives, artillery material, photography, ship-building, railroads, engines, etc. The dictionary is in reality German-Italian etc. and Italian-German etc., running on continuously in one alphabetical order throughout the volume, the initial words being always German or Italian, and never French or English, although the French and English equivalents are added to the German-Italian and Italian-German words.

For greater clearness a short extract from the work is here added, to illustrate the system and arrangement:

Segeltuchbreite f. | *Telo* | Laize de toile | *Breadth of canvas.*

Segheria *f. meccanica* | Das Sägewerk | Scie mécanique | *Sawing-machine.*

Segmentgranate f., s. u. "Geschosse".

Segmenti *m. pl. dell'inviluppo d'un pallone* (*Aër*) | Die Bahnen eines Ballons | Fuseaux | *Patterns; diamonds.*

Segnalazione *f.* | Die Signalisirung | Signalation | *Signalling.*

Segnalazoine *f. semaforica. Bandiere per la* | Die Winkerflaggen (D. Mar.); die Handsignalflaggen | Pavillons de la série sémaphorique | *Signal-flags for semaphoric signalling.*

Segnale *m., v. "Segnale" I. vol. p.* 994.

Segnale a mano; segnale omografico | Das Handsignal; Das Winksignal (mit der Hand gegeben) (D. Mar.) | Signal á bras | *Homographic signal.*

Segnale a petardo | Das Knallsignal;

das Petardensignal | Pétard | *Detonating signal.*

Segnale con fontane | Das Blickfeuersignal | Signal par feux de Bengale | *Signal by blue-lights.*

Segnale con le serie segrete speciali | Das Geheimsignal | Signal secret | *Secret signal.*

Segnale di corsa; segnale di gara, v. "*Bandiera* 3".

Segnale di notte a luce intermittente | Das Nachtsignal mit intermittirenden Lichtern | Signal clignotant | *Night-signal by intermittent lights.*

Segnale distintivo | Das Unterscheidungssignal | Signal particulier | *Distinguishing signal.*

Segnale d'urgenza | Das dringende Signal | Signal urgent | *Urgent signal.*

In character the work is essentially technical, but the time spent in its preparation, the high qualifications of the author (a Captain in the Austrian navy), its official character as issued under the orders of the Navy Section of the Austrian War Department, the immense field it covers, and the fact that it is published under the supervision of the Editor of the excellent periodical *Mittheilungen aus dem Gebiete des Seewesens*, all contribute to render it not only a reliable and valuable contribution to the literature of naval science, but also in large measure a general technological dictionary.

The work is issued in the form of a large octavo volume well printed on good paper, although without illustrations, and bound effectively and attractively. It constitutes an invaluable addition to any scientific, technilogical or naval library, and is quite essential for the study of foreign navies, since the terms in use are not to be found in the ordinary dictionaries.

J. P. W.

Etudes D' Histoire Militaire par F. Lecomte, Colonel Fédéral Suisse. III. Fréderic—Washington—Napoléon. 1900. Lausanne: Librairie F. Rouge. Pp. 527.

Colonel Lecomte of the Swiss army, who died quite recently, was a very prolific military writer, beginning with the history of the campaign in Italy in 1859, which he published in 1860, and his report to the Swiss government on the opening campaigns of our Civil War, made public in 1862, to the present work (his last) issued this year. His works cover, besides the Italian campaign, the entire Civil War, 1861–5, the war with Denmark in 1864, the Campaign of 1866, the Franco-Russian War, the War in the East, 1876–7, as well as studies on the military history of antiquity and the middle ages, Jomini's works and life, and Marbot's memoirs.

His style is essentially critical, so that his account of a campaign is not merely a simple relation of the events, but is at the same time a commentary on them, and since he has all his life been a military student, his essays are valuable in tactics and strategy as well as in pure history.

The present work is part of a collection of studies in military history and comprises critical reviews of the lives and campaigns of Frederick the Great, Washington and Napoleon, together with an estimate of the character of each. The three characters, so strongly marked, yet so entirely distinct, are sketched with a masterly hand, and every American will be proud to read his tribute to our own Washington, whose fine qualities he fully appreciated. The work is a valuable study in military history, graphic in its presentation of the campaigns of these three masters in the art of war, clear in the enunciation of the principles of strategy involved, and true in the estimation of the characters of these great men.

J. P. W.

Siege and Coast Artillery Drill Regulations Compiled for the use of the Cadets. West Point, N. Y. Department of Tactics. Lieut.-Colonel O. L. Hein, Commandant. January, 1900.

A convenient little pamphlet of twenty-three pages, comprising the duties of the gun-commander and gunner, marching maneuvers of the battery, manual of 8-inch rifle, sea-coast mortar, siege rifle, siege howitzer and siege mortar.

J. P. W.

Manual for the Construction of Shelter Trenches, for the use of the Cadets. West Point, N. Y. Department of Tactics.

A timely little work, which will accomplish much if it merely impresses on the Cadets the immense importance of the subject, rendered so evident in the war in South Africa. Indeed, high authorities now demand that the construction of shelter trenches go hand in hand with drill, and that the subject be embodied in the drill regulations.

J. P. W.

Manual for making the Blanket Roll and for Pitching and Striking Shelter Tents. Prepared for the use of the Cadets. West Point, N. Y. Department of Tactics. Lieut.-Colonel O. L. Hein, Commandant.

The Tactical Department at West Point has in the past labored under great disadvantages as regards the *practical* training of the Cadets as soldiers (other than the mere drill of the different arms and guard duty) because the authorities claimed that that was the province of the schools of application. But of late years a more liberal spirit has prevailed, and this Department has been afforded every opportunity to expand and develop. The present Department is evidently giving the Cadets such practical information and instruction as they need most, of which the above useful manual is an example.

J. P. W.

Notes on Horsemanship and Rules for Polo. Prepared for the use of the Cadets by 1st Lieut. R. L. Howze, 6th Cavalry. Department of Tactics. West Point, N. Y. Lieut.-Col. O. L. Hein, Commandant.

This is another very useful little work on a purely practical subject, and one of the greatest importance to all officers. The interest in the subject is increased by introducing the element of sport, an element that must always be carefully fostered in men who are expected to lead an active life of danger and excitement; where it is so necessary to cultivate the spirit of the initiative.

J. P. W.

Manual of U. S. Army, Navy and Marine Corps Retirements. Compiled by Captain Wm. R. Hamilton, 7th Artillery. For sale by Recreation: 23 West 24th Street, New York City. Price: 25 cents.

This pamphlet contains a complete and accurate list of the retirements in the army, navy and marine corps, which will take place from 1900 to 1935 inclusive.

J. P. W.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

A French-English Military Technical Dictionary by Cornélis De Witt Willcox, First Lieutenant of Artillery, United States Army, War Department, Adjutant-General's Office. No. XXIV. Part II, Espace–Palan. 1900. Washington: Government Printing Office.

Revue des Questions Militaires. A new monthly, issued in Paris: Librairie du *Monde Militaire*, G. Kleiner, 6 Rue de la Chaise. Price per year, $3.00.

Le Livre Militaire. A new monthly bibliographical review, issued in Paris: Librairie du *Monde Militaire*, Kleiner, 6 Rue de la Chaise. Price per year, $1.00.

INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

Aldershot Military Society. *Occasional.*
Aldershot. Copies 6d each.

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7*s.*

Army and Navy Gazette. [*A. and N. Gaz.*] *Weekly.*
3 *York Street, Covent Garden, London. Per year* £1 12*s* 6*d.*

Canadian ilitary Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year* £2 6*d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W. C. Per year* £2 6*d.*

Journal of the Royal United Service Institution. [*Jour. R.U.S.I.*] *Monthly.*
22 *Charing Cross, Whitehall, London, S. W. Per year* 24 *s.*

Journal of the United Service Institution of India. [*Jour. U. S. I. India*] *Quarterly.*
Simla, India. Per year $2.50.

Photographic Journal. [*Photo. Jour.*] *Monthly.*
66 *Russell Square, London.*

Proceedings of the Institution of Civil Engineers. [*Proceedings I. C. E.*]
25 *Great George Street, Westminister, London.*

Proceedings of the Institution of Mechanical Engineers.
[*Proceedings I. M. E.*] 19 *Victoria Street, Westminister, London.*

Proceedings of the Royal Artillery Institution. [*Proceedings R. A. I.*] *Monthly.*
Woolwich, England.

Professional Papers of the Corps of Royal Engineers.
[*Prof. Papers Corps Royal Eng'rs.*]
Chatham, England.

Review of Reviews. [*Rev. of Rev. Austral.*] *Monthly.*
169 *Queen Street, Melbourne, Australia. Per year* 11 s. 6 d.

Transactions of the Canadian Institute. [*Trans. Canadian Inst.*]
58 *Richmond Street, Toronto, Canada.*

Transactions of the Canadian Society of Civil Engineers.
[*Trans. Canadian Soc. C. E.*]
Montreal, Canada.

Transactions of the East of Scotland Tactical Society.
[*Trans. E. of S. Tactical Soc.*]
51 *Hanover Street, Edinburgh, Scotland.*

Transactions of the Institute of Naval Architects.
[*Trans. Inst. Naval Architects.*]
5 *Adelphi Terrace, London, W.C.*

United Service Gazette. [*U. S. Gaz.*] *Weekly.*
10, *Wine Office Court, Fleet Street, London, E. C. Per year* £1 10 *s* 6 *d.*

United Service Magazine. [*United Serv. Mag.*] *Monthly.*
13 *Charing Cross, S. W. London. Per year* 27 *shillings.*

FRANCE.

Armée et Marine. [*Armée et Mar.*] *Weekly.*
3 *Place du Théatre Français, Paris, France.*

Le Génie Civil. [*Génie C.*] *Weekly.*
6 *Rue de la Chaussée d'Antin, Paris. Per year* 45 *Fr.*

Le Livre Militaire. [*Livre Mil.*] *Monthly.*
6 *Rue de la Chaise, Paris. Per year* $1.00.

La Marine Française. [*Marine F.*] *Semi-monthly.*
26 *Rue de Grammont, Paris. Per year* 30 *Fr.*

Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils.
[*Ingénieurs Civils.*] *Monthly.*
10 *Cité Rougemont, Paris. Per year* 36 *Fr.*

Mémorial des Poudres et Salpêtres. [*M. Poudres et S.*] *Quarterly.*
Quai des Grands-Augustins, 55, *Paris. Per year* 12 *Fr.*

Le Monde Militaire. [*Monde.*] *Fortnightly.*
6 *Rue de la Chaise, Paris. Per year* 8 *Fr.*

Revue d'Artillerie. [*R. Artillerie.*] *Monthly.*
5 *Rue des Beaux-Arts, Paris. Per year* 22 *Fr.*

Revue de Cavalerie. [*R. Cav.*] *Monthly.*
Berger Levrault et Cie, Rue des Beaux-Arts 5, *Paris. Per year* 33 *Fr.*

Revue du Cercle Militaire. [*Cercle.*] *Weekly.*
37 *Rue de Bellechasse, Paris. Per year* 27 *Fr.*

Revue du Génie Militaire. [*Génie M.*] *Monthly.*
8 *Rue Saint-Dominique, Paris. Per year* 27 *Fr.*

Revue d'Infanterie. [*R. Inf.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Revue Maritime. [*R. Maritime.*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 56 *Fr.*

Revue Militaire. [*R. Mil. France.*] *Monthly.*
R. Chapelot et Cie., 30 *rue et passage Dauphine, Paris. Per year* 20 *Fr.*

Revue Militaire de l'Etranger. [*Etranger.*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 15 *Fr.*

Revue Militaire Universelle. [*R. Univ.*] *Monthly.*

Revue des Questions Militaires. [*Quest. Mil.*] *Monthly.*
6 *Rue de la Chaise, Paris. Per year* $3.00.

11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Le Yacht—Journal de la Marine. [*Yacht.*] *Weekly.*
55 *Rue de Chateaudun, Paris. Per year* 30 *Fr.*

GERMANY.

Allgemeine Militaer-Zeitung. [*A. M.-Zeitung.*] *Semi-weekly.*
Darmstadt. Per year 24 *M.*

Beiheft zum Militaer-Wochenblatt. [*Beiheft.*]
Koch Strasse, 68, *S. W.*, *Berlin.*

Deutsche Heeres-Zeitung. [*Heeres-Zeit.*] *Semi-weekly.*
Wilhelmstrasse 15, *Berlin. Per year* $6.00.

Illustrirte Aeronautische Mittheilungen. [*Aeronaut. Mitth.*] *Quarterly.*
Kalbgasse 3, *Strassburg i. E. Germany. Per year* $1.70.

Internationale Revue. [*Int. Revue.*] *Monthly.*
Blasewitzer Strasse 15, *Dresden. Per quarter* 8 *Fr.*

Jahrbuecher fuer die deutsche Armee und Marine. [*Jahrbuecher.*] *Monthly.*
Mohren Strasse, 19, *Berlin*, *W.* 8. *Per year* 32 *M.*

Kriegstechnische Zeitschrift. [*Kriegstech.*] *Ten numbers a year.*
Koch Strasse, 68-71, *Berlin. Per year* 10 *M.*

Marine Rundschau. [*Mar. Rundschau.*] *Monthly.*
Koch Strasse, 68-70, *Berlin. Per year* 3 *M.*

Militaer-Wochenblatt. [*Wochenblatt.*] *Semi-weekly.*
Koch Strasse, 68, *Berlin*, *S. W.* 12. *Per Year* 20 *M.*

Stahl und Eisen. [*Stahl u. Eisen.*] *Fortnightly.*
Schadenplatz 14, *Düsseldorf. Per year* $5.00.

Umschau, Die. [*Umschau.*] *Weekly.*
Frankfort a. M. Per year 10 *M.*

AUSTRIA.

Mittheilungen ueber Gegenstaende des Artillerie und Genie-Wesens.
[*Mitth. Art. u. G.*] *Monthly.*
Wien, *VI*, *Getreidemarkt* 9. *Per year* 1 *Fl.* 50 *Kr.*

Mittheilungen aus dem Gebiete des Seewesens. [*Seewesens.*] *Monthly.*
Pola. Per year 14 *M.*

Organ der Militaer Wissenchaftlichen Vereine. [*Vereine.*]
Wien I, *Stauchgasse No.* 4. *Per year*, 8-14 *numbers*, 6 *Fl.*

Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines.
[*Z. Architek. Ver.*] *Weekly.*
I. Eschenbachgasse, *No.* 9, *Wien. Per year* 10 *Fl.*

SWITZERLAND AND BELGIUM.

Allgemeine Schweizerische Militaer-Zeitung. [*A.S.M. Zeitung.*] *Weekly.*
Basel, *Switzerland. Per year*, 8 *Fr.*

La Belgique Militaire. [*Belgique M.*] *Weekly.*
Rue St. Georges 32, *Ixelles*, *Belgium. Per year* 12.50 *Fr.*

Monatschrift fuer Offiziere Aller Waffen. [*Monatschr.*] *Monthly.*
Frauenfeld, *Switzerland. Per year* 5 *Fr.*, *plus postage.*

Revue de l'Armée Belge. [*A. Belge.*] *Bi-monthly.*
22 *Rue des Guillemins*, *Liège*, *Belgium. Per year* 13 *Fr.*

Revue Militaire Suisse. [*R. M. Suisse.*] *Monthly.*
Escalier-du-Marché, *Lausanne*, *Switzerland. Per year* 10 *Fr.*

Schweizerische Militärische Blätter. (Including *Schweizerische Zeitschr. für Art. u. G.*, and *Monatschr. für Offiziere aller Waffen*).
[*Schweiz. Mil. Blaetter.*] *Monthly. Frauenfeld*, *Switzerland.*
Per year 8 *Fr.* 20 *Cents.*

Schweizerische Zeitschrift fuer Artillerie und Genie. [*S. Zeitschrift.*] *Monthly.*
Frauenfeld, Switzerland. Per year 8 *Fr.* 20 *centimes.*

SPAIN, PORTUGAL AND SOUTH AMERICA.

Boletin del Centro Naval. [*Boletin, Argentina.*] *Monthly.*
438 *Alsina, Buenos Aires, Argentina Republica. Per year* $11.00.

Boletin Militar. [*Boletin, Mexico.*] *Weekly.*
Calle de San Rafael 2821, *Mexico. Per year* $6.00.

Circulo Naval,—Revista de Marina. [*Circulo Naval.*] *Monthly.*
Casilla num. 852, *Valparaiso, Chili.*

Memorial de Artilleria. [*M. de Art.*] *Monthly.*
Farmacia, num. 13, *Madrid, Spain. Per year, U. S.,* $3.40.

El Porvenir Militar. [*Porvenir.*] *Weekly.*
258 *Calle Montevideo, Buenos Aires, Argentina. Per year* 10 $ m/n .

Revista Cientifico-Militar. [*Cientifico M.*] *Semi-monthly.*
5 *Calle de Cervantes, Barcelona, Spain. Per year* 32 *Fr.*

Revista de Engenheria Militar. [*Engenheria Mil.*] *Monthly.*
27 *Rua Nova do Almada, Lisbon, Portugal. Per year* 1 $ 800 *réis.*

Revista do Exercito e da Armada. [*Exercito.*] *Monthly.*
Largo de S. Domingos No. 11, *Lisbon, Portugal. Per year U. S.* $6.00.

Revista General de Marina, [*R. G. de Marina.*] *Monthly.*
56 *Calle de Alcalá, Madrid, Spain. Price U. S.* $4.45.

Revista Maritima Brazileira. [*R. Marit. Brazil.*] *Bi-monthly.*
Rue do Conseheiro Saraiva n. 12, *Rio de Janeiro, Brazil. Per year* $1.575.

Revista Militar. [*R. Mil. Portugal.*] *Semi-monthly.*
262 *Rua da Princeza, Lisbon, Portugal. Per year,* $2.60.

Revista Militar. [*R. Mil. Brasil.*] *Monthly.*
Rio de Janeiro, Brasil. Per year

Revista Militar y Naval. [*R. Mil. y Nav.*] *Semi-Monthly.*
Calle Colonia, No. 379 *A. Montevideo, Uraguay.*

HOLLAND AND SCANDINAVIA.

Artilleri-Tidskrift. [*Art. Tids.*] *Bi-monthly.*
Artillerigården Stockholm, Sweden. Per year, U. S., $1.75.

De Militaert Gids. [*M. Gids.*] *Bi-monthly.*
De Erven F. Bohn, Haarlem, Holland. Per year, U. S., $2.00.

Militaert Tidsskrift. [*M. Tids.*] *Bi-monthly.*
Copenhagen, Denmark. Per year, U. S., $2.50.

Norsk Militaert Tidsskrift. [*N. M. Tids.*] *Monthly.*
Christiania, Norway. Per year, U. S., $2.50.

RUSSIA.

Artilleriiskii Journal. [*Rus. Art. Jour.*] *Monthly.*
Furschtatskaia Ulitza, St. Petersburg, Russia.

Razviedchik. [*Razv.*]
KoloKolwaia Ulitza, No. 14, *St. Petersburg, Russia.*

Russkii Invalide. [*Invalide.*]
Wadizdinskia Ulitza, No. 48, *St. Petersburg, Russia.*

ITALY.

Rivista di Artiglieria é Genio. [*R. Artig.*] *Monthly.*
Tipografia Voghera Enrico, Rome. Per year 30 *L.*

La Corrispondenza. [*Corrispondenza*]. *Monthly.*
1 *Rue de Rome, Livorno, Italy. Per year* $5.00.

Rivista Marittima. [*R. Maritt.*] *Monthly.*
Rome. Per year 25 *L.*

UNITED STATES.

American Journal of Mathematics. [*Jour. Math.*] *Quarterly.*
John Hopkins University, Baltimore, Md. Per year $5.00.

American Machinist. [*Amer. Mach.*] *Weekly.*
256 *Broadway, New York City. Per year* $3.00.

American Manufacturer and Iron World. [*Man. and Iron World.*] *Weekly.*
55 *Ninth Street, Pittsburgh, Pa. Per year* $4.00.

Annual of the Office of Naval Intelligence. [*Naval Intelligence.*]
Washington, D. C.

Army and Navy Journal. [*A. and N. J.*] *Weekly.*
New York City. Per year $6.00.

Army and Navy Register. [*A. and N. R.*] *Weekly.*
Washington, D. C. Per year $3.00.

Bulletin of the American Mathematical Society. [*Bulletin Math. Soc.*]
University Heights, New York City. Ten numbers per year. $5.00 *per year.*

Cassier's Magazine. [*Cas. Mag.*] *Monthly.*
3, *West* 29*th Street, New York City. Per year* $3.00.

Electrical World and Electrical Engineer. [*Elec. Eng.*] *Weekly.*
9 *Murray Street, New York City. Per year* $3.00.

Electrical Engineering. [*Elec. Eng'ing.*] *Monthly.*
Monadnock Block, Chicago, Ill. Per year $1.00.

Electrical Review. [*Elec. Rev. N. Y.*] *Weekly.*
41 *Park Row, New York City. Per Year* $3.00.

The Engineer. [*Eng. Cleve.*] *Fortnightly.*
Blackstone Building, Cleveland, Ohio. Per year $2.50.

Engineering Magazine. [*Eng'ing. Mag.*] *Monthly.*
120-122 *Liberty Street, New York City. Per year* $3.00.

Engineering News and American Railroad Journal.
[*Eng'ing News.*] *Weekly.*
220 *Broadway, New York City. Per year* $5.00.

Engineering and Mining Journal. [*Eng. and Min. Jour.*] *Weekly.*
253 *Broadway, New York City. Per year* $5.00.

The Iron Age. [*Iron Age.*] *Weekly.*
232-238 *Williams Street, New York City. Per year* $4.50.

Journal of Electricity. [*Jour. Elec.*] *Monthly.*
421 *Market Street, San Francisco, Cal.*

Journal of the American Chemical Society. [*J. Chem. S.*] *Monthly.*
Easton, Pa. Per year $5.00.

Journal American Society of Naval Engineers. [*A.S.N. Egrs.*] *Quarterly.*
Navy Department, Washington, D. C.

Journal of the Association of Engineering Societies. [*Eng. Soc.*] *Monthly*
257 *South Fourth Street, Philadelphia. Per year* $3.00.

Journal of the Franklin Institute. [*Frank. Inst.*] *Monthly.*
Philadelphia, Pa., Per year $5.00.

Journal of the Military Service Institution. [*Jour. M. S. I.,*] *Bi-monthly.*
Governor's Island, New York City. Per year $4.00.

Journal of the U.S. Cavalry Association. [*Jour. U. S. Cavalry*] *Quarterly.*
Fort Leavenworth, Kansas.

Journal of the Western Society of Engineers. [*W. Soc. Eng.*] *Bi-monthly.*
1737 *Monadnock Block, Chicago, Illinois. Per year* $2.00.

Marine Review. [*Mar. Rev.*] *Weekly.*
Cleveland, Ohio. Per year $2.00.

Military Information Division. [*Mil. Information Div.*] *Occasional.*
War Department, Washington, D. C.

Mines and Minerals. *Monthly.*
Scranton, Penn. Per year $2.00.

New South. *Monthly.*
Nashville, Tenn. Per Year $1.00.

Notes on Naval Progress. [*Naval Intelligence.*] *Occasional.*
Navy Department, Washington, D. C.

Pennsylvania Magazine of History and Biography. [*Penn. Mag. of Hist.*
Quarterly.
13 *Locust Street, Philadelphia. Per year* $3.00.

The Photographic Times. [*Phot. Times.*] *Weekly.*
60 *and* 62 *E.* 11*th Street, New York City. Per year* $5.00.

Physical Review. [*Phys. Rev.*] *Ten numbers per year.*
Cornell University, Ithaca, New York. Per year $5.00.

Popular Science Monthly. [*Pop. Sc. Mo.*] *Monthly.*
72 *Fifth Avenue, New York City. Per year* $5.00.

Proceedings of the American Philosophical Society.
[*Proceedings of A. Phil. Soc.*]
104 *South Fifth Street, Philadelphia, Pa.*

Proceedings of the American Society of Civil Engineers.
[*Proc. A. S. Civil Engr's.*] *Monthly.*
220 *West* 57*th Street, New York City.*

Proceedings of the U. S. Naval Institute. [*Naval Inst.*] *Quarterly.*
Annapolis, Md. Per year $3.50.

Public Opinion. [*Pub. Opin.*] *Weekly.*
New York City. Per year $2.50.

Review of Reviews. *Monthly.*
13 *Astor Place, New York City. Per year* $2.50.

The Scientific American. [*Scien. Amer.*] *Weekly.*
361 *Broadway, New York City. Per year* $3.00.

Shooting and Fishing. *Weekly.*
293 *Broadway, New York City. Per year* $3.50.

Technology Quarterly. [*Tech. Quart.*] *Quarterly.*
Mass. Inst. of Tech., Boston, Mass. Per year, $3.00.

Telephone Magezine, Illustrated, [*Telephone Mag.*] *Monthly.*
Marquette Building, Chicago, Ills. Per year $1.00.

Transactions American Institute of Electrical Engineers.
[*Inst. Elec. Eng'rs.*] *Monthly.*
26 *Cortlandt Street, New York City. Per year* $5.00.

Transactions American Institute of Mining Engineers.
[*Trans. Inst. Min. Eng'rs.*]
99 *John Str., New York City.*

Transactions of the American Society of Civil Engineers.
[*Trans. A. S. Civil Eng'rs*]
220 *West* 57*th Street, New York City.*

Transactions of the American Society of Mechanical Engineers.
[*Trans. A. S. Mech. Eng'rs.*]
12 *West* 31*st Street, New York City.*

Transactions of the Society of Naval Architects and Marine Engineers.
[*Naval Architects and Marine Eng'rs.*]
12 *West* 31*st Street, New York City.*

Western Electrician. [*West. Elec.*] *Weekly.*
510 *Marquette Building, Chicago, Illinois. Per year* $3.00.

Wilson's Photographic Magazine. [*Phot. Mag.*] *Monthly.*
853 *Broadway, New York City. Per year* $3.00.

ORGANIZATION AND ADMINISTRATION.

The German field artillery in 1900.—**Cercle,** February 1.
Mounted Infantry.—**Invalide,** No. 8.
The National Guard.—**Mil. Serv. Inst.,** March.
The foreign navies in 1899.—**Mar. Rundschau,** March.
A squadron of Sphahis.—**Armée et Marine,** March 18.
Germany's naval programme—a lesson for the U. S.—**Scien. Amer.,** March 31.
Organization of the field artillery.—**M. Tids.,** 2.
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